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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LIII. No. 7. MAY 1893.

Fellows of the Society are informed that post-cards containing the titles of papers to be read at the evening meetings will be sent to those who shall express their wish to receive them. Fellows desiring to receive the post-cards are requested to send their names to the Assistant-Secretary, Mr. W. H. Wesley, Burlington House, London, W.

In order to enable the Secretaries to prepare complete lists in time for the issue of the post-cards, authors are particularly requested to send in their papers not later than the Tuesday preceding the day of meeting.

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VOL. LIII. MAY 12, 1893. No. 7

Captain W. de W. ABNEY, C.B., R.E., D.C.L., F.R.S., President, in the Chair.

Walter Frederick Gale, M.R.S. of N.S.W., The Observatory, Paddington, New South Wales, Australia;
The Rev. P. H. Kempthorne, M.A., Wellington College, Berks;
James Henry Young, B.Sc. (Lond.), The Dell, Tooting Graveney, Surrey,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

William Murray Dobie, M.D., J.P., Northgate House, Chester (proposed by George Knott);
Roland Pillans, Geodetic Survey, Royal Observatory, Cape of Good Hope (proposed by David Gill);
Dr. Charles Lane Poor, Astronomer in the Johns Hopkins University, Baltimore, M.D., U.S A. (proposed by Harold Jacoby);
Thomas Jefferson Jackson See, Ph.D., University, Chicago, U.S.A. (proposed by S. W. Burnham);
Louis Heathcote Walter, 56 Victoria Street, Westminster, S.W. (proposed by George Calver).

Eighty-two presents were announced as having been received since the last meeting, including, amongst others :—

Greenwich Observations, 1890, presented by the Observatory; Annals of the Cape Observatory, vol. i. part 2, presented by the Observatory; H. Jacoby, the parallaxes of μ and θ *Cassiopeiæ*, deduced from the Rutherfurd photographic measures, presented by the author ; Potsdam Astrophysical Observatory, Publications, vol. viii. ; Lick Observatory, original negatives of *Jupiter*, and enlargements of photographs of *Jupiter*, &c., presented by the Observatory; Lick Observatory photograph of *Jupiter*, enlargement made and presented by A. Stanley Williams, Esq. ; Lick Observatory photographs of the Moon, series of enlargements made and presented by Baron Albert Rothschild ; series of photographs made by Dr. Warren De la Rue during the total solar eclipse of 1860 July 18, and a photograph of Dr. De la Rue, presented by Thomas De la Rue, Esq. ; a 10-inch brass pillar sextant by Troughton, and a double sextant by Cary, bequeathed by the late A. E. Nevins, Esq.

Note on the Determination of the Moon's Mass. By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

In *Gould's Astronomical Journal*, No. 289, Professor G. W. Hill has given a determination of the Moon's mass from the values of the constants of Precession and Nutation which are at present generally accepted.

In this paper the approximations are pushed to the seventh order of small quantities, and although, from the fact that Delaunay's expressions of parallax are only pushed to the fifth order of small quantities, no reliance can be placed on the absolute accuracy of the terms of the sixth and seventh orders, the result is probably the most accurate which has yet been obtained.

But Professor Hill in this paper expresses an opinion that in previous investigations the undisturbed elliptic co-ordinates of the Moon had alone been employed. This is certainly not the case in the investigation, the results of which are given in the *Monthly Notices R.A.S.*, vol. xxviii. p. 42. In this investigation I used Delaunay's co-ordinates, and my results should be identical with Professor Hill's to the order of approximation to which I proceeded, which was the third. On examination I find such to be the case, although the agreement is slightly disguised by the introduction of two different constants ϵ and ϵ', which have to be found from observations by a comparison between the theoretical results and the constants of precession and nutation.

To make the comparison easy between my results and those

which I had obtained from Serret's formulæ, *Monthly Notices*, vol. xxviii. p. 25, I introduced the constant

$$\epsilon = \frac{\text{Moon's mass}}{\text{Sun's mass}} \cdot \frac{(\text{mean distance of Sun})^3}{(\text{mean distance of Moon})^3}.$$

The exact meaning of the expressions "mean distances of the Sun and Moon" being defined by the conditions that if a' and D′ denote these distances, a the equatorial radius of the Earth, and π and C the constants of solar and lunar parallax

$$\sin 1'' \cdot \pi = \frac{a}{a'}; \quad \sin 1'' \cdot C = \frac{a}{D}.$$

But Professor Hill has practically introduced a constant

$$\epsilon' = \frac{\text{Moon's mass}}{\text{Sun's mass}} \cdot \frac{a_1^3}{a^3},$$

where a is the constant introduced in Delaunay's Theory as satisfying the condition

$$\text{Moon's mass} = n^2 a^3,$$

where n is the Moon's mean motion in longitude; but we have in *Delaunay's Lunar Theory*, vol. ii. p. 914,

$$\sin 1'' \cdot C = \frac{a}{a}\left(1 + \frac{m^2}{6} + \frac{m^2 e_1^2}{4} - \frac{179}{288}m^4 - \frac{97}{48}m^5\right) = \frac{a}{D}$$

$$\therefore \frac{a}{D} = \left(1 + \frac{m^2}{6} + \frac{m^2 e_1^2}{4} - \frac{179}{288}m^4 - \frac{97}{48}m^5\right)$$

But

$$\frac{\epsilon}{\epsilon_1} = \frac{a^3}{D^3} = \left(1 + \frac{m^2}{6} + \&c.\right)^3$$

or

$$\epsilon = \epsilon'\left(1 + \frac{m^2}{6} + \&c.\right)^3 = \epsilon'\left(1 + \frac{m^2}{2} + \&c.\right)$$

If we substitute this value of ϵ in the equations

$$\text{Luni-solar precession} = \kappa\left(1 + \frac{3e_1^2}{2}\right) + \kappa\epsilon\left(1 + \frac{3e^2}{2} - 6\gamma^2\right)$$

$$\text{Nutation} = \kappa\epsilon\frac{2\gamma}{\mu}\left[1 + \frac{3e^2}{2} - \frac{5\gamma^2}{2}\right]$$

given in my paper, we have to the third order of small quantities

$$\text{Luni-solar precession} = \kappa\left[1 + \frac{3e_1^2}{2}\right] + \kappa\epsilon'\left[1 + \frac{m^2}{2} + \frac{3e^2}{2} - 6\gamma^2\right]$$

$$\text{Nutation} = \kappa\epsilon'\frac{2\gamma}{\mu}\left[1 + \frac{m^2}{2} + \frac{3e^2}{2} - \frac{5\gamma^2}{2}\right],$$

expressions which are identical to the same order of approximation with those given by Professor Hill.

On the Distribution of Temperature in the Transit-circle Room at the Royal Observatory, Greenwich. By H. H. Turner, M.A., B.Sc.

It has been mentioned in recent Reports of the Council (*Monthly Notices*, vol. xlix. p. 175, vol. l. p. 185, vol. li. p. 208) that experiments were in progress on the distribution of temperature in the transit-circle room at the Royal Observatory, Greenwich. A few observations of this kind were made in 1879 May and June, but the investigation was not carried further when it was found that there was no serious anomaly in the gradual diminution of temperature outwards from the instrument. But for several reasons it has seemed advisable to inquire more closely into the matter.

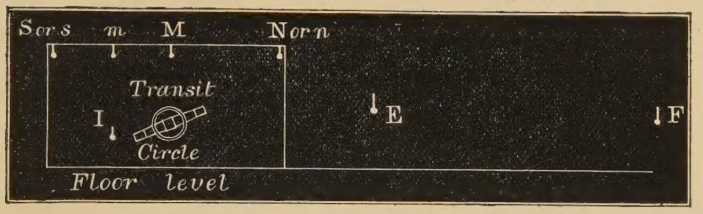
Six thermometers in all were read as nearly simultaneously as practicable, two or three times in the course of the evening, by the transit-circle observer. Three of them are in general use for computing refraction: viz. the interior thermometer (I) placed near the instrument, the exterior thermometer (E), near the north wall of the room, and the Front Court thermometer (F) mounted on a post with a revolving shade to protect it from the Sun, 53 feet from the exterior north wall of the transit-circle room. The other three thermometers were placed in the shutter opening along the horizontal roof of the transit-circle room—one (N) at the north corner, another (M) in the middle, and the third (S) at the south corner. It was soon found that there was a systematic difference between the readings of (N) and (S); that is to say, the distribution of temperature was not symmetrical in the north and south direction. To eliminate any effect of residual index error on this difference the thermometers (N) and (S) were in 1890 January interchanged. At the same time the thermometer (M) was removed from its central position and placed further to the south, directly over the thermometer (I), but still in the shutter opening. In these new positions the thermometers are designated (*n*), (*m*), and (*s*). The following table gives all requisite information as to the identity and position of the six thermometers:—

TABLE I.

Distinguishing Letter.	Number.	Index Correction.	Distance from Centre of Transit Circle. North.	East.	Above.
		°	ft.	ft.	ft.
I	12264	−0·5	− 7·3	+ 2·4	− 0·6
E	45357	−0·2	+23	+ 2·6	+ 1·0
F	44520	−0·3	+71	−36	− 0·5
N	A2637	−0·2	+17·5	+ 0·5	+13
M	A2645	−0·2	0 0	− 0·5	+13
S	A2640	−0·2	−17·5	+ 0·5	+13
n	A2640	−0·2	+17·5	+ 0·5	+13
m	A2645	−0·2	− 7·3	− 0·5	+13
s	A2637	−0·2	−17·5	+ 0·5	+13

The numbers are those assigned by Messrs. Negretti and Zambra, by whom all the thermometers were made. The index corrections are adopted from comparisons with the standard thermometer on 1889 March 15.

The following diagram shows the approximate positions of the thermometers projected on the meridian plane.



It soon became apparent that very anomalous results were obtained if some of the six shutters of the transit-circle room were left closed. The best conditions for observation are undoubtedly when the room has been thrown open to the external air as much as possible for a considerable time; but these conditions are not always attainable in practice. In bad weather the shutters are sometimes thrown open for a few minutes only, to snatch an observation between clouds, or even between showers; and on windy nights it is often necessary, in observing stars by reflexion, to close the shutters behind the observer. Shutters not actually interfering with observations at the time may again be left closed inadvertently; and, generally speaking, there are so many observations made in conditions when the circulation of air has been restricted that a complete investigation should include a determination of the effect of such restrictions. This may be undertaken later, but throughout the period here under discussion the thermometers were directed to be read only when all the shutters had been open for at least 15 minutes, and the actual time elapsed since opening was to be noted.

The observations were collected in groups according to the reading of (F) the front court thermometer (each group extending over 5°), and the following tables exhibit the mean excess of each thermometer over (F), corrected for index error:—

TABLE II.

1888 *April* 1, *to* 1889 *December* 31.

	Mean Reading of F.	No. of Obs.	I	Mean Excess over F of M	N	S	E
	28°3	9	+4°34	+2°92	+1°79	+1°17	+0°62
	32·5	18	+3·36	+1·87	+1·46	+1·14	+0·39
	37·7	36	+3·04	+1·65	+1·03	+1·02	+0·17
	42·5	62	+3·01	+1·40	+1·17	+0·76	+0·07
	47·3	60	+2·72	+1·19	+0·85	+0·67	−0·08
	52·7	68	+2·71	+0·94	+0·88	+0·42	−0·13
	57·4	43	+2·13	+0·74	+0·67	+0·32	−0·06
	62·0	24	+1·38	+0·48	+0·15	−0·10	−0·66
	66·6	5	+1·06	+0·82	+0·64	+0·30	−0·58
Simple Mean	47·4		+2·64	+1·33	+0·96	+0·63	−0·03

TABLE III.

1890 *January* 1, *to* 1891 *March* 31.

	Mean Reading of (F)	No. of Obs.	I	Mean Excess over F of *m*	*n*	*s*	E
	23°8	6	+4°23	+3°62	+2°40	+1°67	+1°10
	27·1	2	+4·45	+2·40	+2·00	+1·25	+0·85
	32·8	13	+3·31	+2·14	+1·52	+0·92	+0·26
	37·2	32	+3·15	+1·74	+1·19	+1·07	+0·31
	43·0	25	+3·25	+1·77	+1·12	+0·87	+0·23
	47·4	34	+3·18	+1·61	+1·03	+0·63	−0·03
	51·9	24	+2·85	+1·05	+0·78	+0·37	+0·11
	56·7	26	+2·55	+0·97	+0·75	+0·38	+0·17
	61·6	8	+2·13	+1·44	+1·11	+0·50	−0·11
Simple Mean	42·4		+3·23	+1·86	+1·32	+0·85	+0·32

Several general features of these tables are somewhat striking. We may first notice the excess of N over S, and n over s. As above remarked, the index error affects these excesses in opposite directions; and we may use these observations to determine the difference of residual index errors. If this difference be e, we have

$$(N-S)-(n-s)=2e$$

The value of e deduced from the various groups is exhibited in the following table:—

TABLE IV.

Limits of Reading of F.	N−S.	No. of Obs. $=p$	$n-s$.	No. of Obs. $=q$	½ (Diff.) $=e$	Weight. $=\frac{2pq}{p+q}$
° °	°		°		°	
20−30	+0·62	9	+0·73	8	−0·06	8
30−35	+0·32	18	+0·60	13	−0·14	15
35−40	+0·01	36	+0·12	32	−0·06	34
40−45	+0·41	62	+0·25	25	+0·08	35
45−50	+0·18	60	+0·40	34	−0·11	43
50−55	+0·46	68	+0·41	24	+0·02	35
55−60	+0·35	43	+0·37	26	−0·01	34
60−70	+0·27	29	+0·61	8	−0·17	13
	Weighted Mean		... ...	...	−0·05	

Since the readings of the thermometers were only estimated to tenths of a degree in the comparison on 1889 March 15, this result may be considered satisfactory; and we may presume that

(1) The index errors of the thermometers are determined to within 0°·1.

(2) The graduation of the thermometers is satisfactory, and correct standard readings are given by the application of a uniform index error as above.

The second noticeable feature of the tables is the nearly uniform decrease of the excesses with the rise of mean temperature. Linear equations were deduced from the observations as follows: the simple means shown at the foot of Tables II. and III. were subtracted from the numbers in the columns above them; and the signs of the results changed when that in column (1) was negative. Thus all the results for column (1), and nearly all those for the other columns, are now positive; and the sum of the members of any column, say E, divided by the sum of column (1) gives the rate of decrease of E−F per degree of F. This process is nearly equivalent to that of least squares and very much less cumbersome, while probably sufficiently accurate for the purpose. The groups are weighted equally instead of as their distance from the mean, but on the other hand no allowance has been made for the fact that the number of observations is smaller for the extreme groups than for the others. The following are the resulting equations:—

From Table II.	*From Table III.*
$I-F=(87^{\circ}3-F)\times 0{\cdot}066$	$I-F=(112^{\circ}9-F)\times 0{\cdot}045$
$M-F=(74{\cdot}2-F)\times 0{\cdot}049$	$m-F=(79{\cdot}6-F)\times 0{\cdot}050$
$N-F=(78{\cdot}3-F)\times 0{\cdot}031$	$n-F=(79{\cdot}5-F)\times 0{\cdot}035$
$S-F=(67{\cdot}3-F)\times 0{\cdot}031$	$s-F=(69{\cdot}5-F)\times 0{\cdot}031$
$E-F=(48{\cdot}4-F)\times 0{\cdot}027$	$E-F=(55{\cdot}4-F)\times 0{\cdot}024$

and these expressions give the following residuals:—

TABLE V.

Residuals for Table II.

Mean Reading of F.	I	M	N	S	E
28°3	+0°44	+0°64	+0°24	−0°06	+0°13
32·5	−0·26	−0·20	+0·04	+0·04	+0·01
37·7	−0·24	−0·16	−0·23	+0·08	−0·07
42·5	+0·05	−0·17	+0·06	−0·02	−0·03
47·3	+0·07	−0·15	−0·11	+0·04	−0·05
52·7	+0·42	−0·13	+0·08	−0·04	+0·05
57·4	+0·15	−0·09	+0·02	+0·01	+0·24
62·0	−0·29	−0·12	−0·36	−0·27	−0·23
66·6	−0·31	+0·44	+0·28	+0·27	−0·02

TABLE VI.

Residuals for Table III.

Mean Reading of F.	I	*m*	*n*	*s*	E
23°8	+0°15	+0°83	+0°42	+0°24	+0°32
27·1	+0·52	−0·22	+0·14	−0·08	+0·15
32·8	−0·36	−0·20	−0·12	−0·23	−0·30
37·2	−0·32	−0·38	−0·32	+0·06	−0·14
43·0	+0·05	−0·06	−0·20	+0·02	−0·09
47·4	+0·17	0·00	−0·12	−0·07	−0·23
51·9	+0·06	−0·34	−0·20	−0·18	+0·02
56·7	−0·03	−0·18	−0·06	−0·02	+0·20
61·6	−0·22	+0·54	+0·47	+0·25	+0·04

The residuals seem to indicate that, in some cases at least, a curve would suit the observations better than a straight line, more especially those for M and *m*, though here an allowance for large accidental error in the terminal groups, where the observations are not numerous, would do almost equally well. At any rate, straight lines give a very good first approximation.

Considering now the various thermometers in turn, we remark first the discordance between the two results for I. No change was made during the observations which can be assigned as a cause for this difference, which is apparently accidental. The residuals for I are numerically larger than those for all the other thermometers except *m*, as might be expected from the fact that it is nearer disturbing causes—gas jets, and the observer's body, &c. Taking a mean between the two expressions,

viz.: I–F = (100° – F) × ·005, and comparing this with both tables, we get the following residuals:—

Table VII.

Limits of Reading of F.	Table II.	Table III.
° °	°	°
20–25	...	+0·04
25–30	+0·39	+0·40
30–35	−0·36	−0·39
35–40	−0·41	−0·31
40–45	−0·16	+0·11
45–50	−0·18	+0·28
50–55	+0·10	+0·20
55–60	−0·22	+0·16
60–65	−0·71	+0·01
65–70	−0·78	...

from which it appears that the discordance is chiefly due to the observations at high temperatures in the summer: for as far as 45° the accordance is striking.

The expressions for M and *m* relate to the same thermometer in different positions; but, curiously enough, though *m* was south of M, and its readings might have been expected (from the marked excess of N over S) to be smaller than those of M, we find them actually larger by the nearly constant quantity 0°·20. On examining the situation of *m*, it was noticed that a metal pipe, which carries off the products of combustion of a gas flame used to illuminate the clock, passes within 3 or 4 feet of *m*, while this and other similar pipes do not pass near any of the other thermometers; and it is probably the influence of this heated pipe which raises the temperature at *m* some half a degree above that which we should expect by interpolation between M and S.

The expressions for N and *n* and for S and *s* are satisfactorily accordant; while in the case of E we encounter a discordance similar to that for I, though less conspicuous in amount: viz. the factor for E from Table III. is smaller, while the reading of F at which I–F vanishes is larger than for Table II. Something would therefore seem to have affected E and I differently in the two series of observations, leaving N and S undisturbed (about M, whose position was changed, we can say nothing). The accordance of N with *n* and S with *s* is also significant as showing that the readings of F in the two series are comparable. The thermometers were all referred to F because the conditions of its exposure most nearly approach standard conditions. Some slight changes were, however, made in the exposure of F during the observations. In 1888 July a transit hut for longitude observations was erected near F to the east; and in 1888 Septem-

ber another hut to the N.-W. of the post carrying F. The latter hut was removed in 1889 August, but the former remained throughout, and on 1890 February 28 the post carrying the thermometer F was dug up and removed to a greater distance from this hut, the neighbourhood of which might, it was feared, be influencing the exposure of F. But this does not seem to have been the case. We must look to some accidental feature of the weather for the changes in I and E, or, perhaps, to the fact that Table II. is based on observations in two summers and a winter, Table III. on two winters and a summer. The discussion which follows, of the effect of the seasons on the thermometers, will elucidate this point.

Before passing, however, to this discussion it is to be remarked that there is a physical significance for the constants in the linear equations on p. 427, and especially for the constant within the brackets. It is the standard external temperature at which the point of suspension of any thermometer is sensibly at the temperature of the external air. If we regard any thermometer as being disturbed by a single source of heat, this temperature should be that of the disturbing source. There are, of course, several such disturbing sources, viz., gas flames, the observer's body, and the walls of the room; and the significance of the constant within brackets is thus somewhat complex. But it is satisfactorily in accordance with this interpretation that the value of the constant should be large for I and small for E; for I is presumably disturbed by sources of high temperature, such as gas flames, while E is disturbed by sources of low temperature, probably the external walls of the building. Since the sub-permanent temperature of these walls must be different in winter and summer, the discussion of the seasonal effect will throw more light on this point.

If the mean of the readings in each calendar month be taken we get the following results :—

Table VIII.

1888.	Mean Excess over F of					Mean Reading of F
	I	M	N	S	E	
Apr.	+2·84	+1·83	+1·60	+0·85	+0·35	42·4
May	+2·79	+1·22	+0·80	+0·55	+0·11	49·4
June	+2·35	+0·58	+0·85	+0·24	+0·13	55·3
July	+2·35	+0·85	+1·05	+0·46	+0·08	54·4
Aug.	+2·34	+1·21	+0·78	+0·47	−0·54	57·4
Sept.	+2·75	+0·96	+0·90	+0·86	−0·33	52·2
Oct.	+2·12	+0·80	+0·64	+0·30	−0·50	46·7
Nov.	+2·73	+1·03	+0·87	+0·70	0·00	44·0
Dec.	+2·87	+1·37	+1·00	+1·07	−0·05	40·9

1889.	Mean Excess over F of I	M	N	S	E	Mean Reading of F
Jan.	+1·96	+0·98	+0·63	+0·73	+0·23	36·9
Feb.	+2·01	+0·85	+0·77	+0·52	+0·56	36·6
Mar.	+2·76	+1·47	+0·92	+0·81	−0·02	38·6
Apr.	+2·90	+1·40	+1·02	+0·61	−0·15	43·3
May	+2·59	+1·08	+0·60	+0·28	−0·57	52·1
June	+1·79	+0·66	+0·39	−0·14	−0·60	57·9
July	+2·70	+0·96	+0·42	+0·15	−0·23	58·7
Aug.	+2·93	+1·05	+1·05	+0·24	−0·32	57·4
Sept.	+2·72	+1·42	+0·50	+0·76	−0·14	53·4
Oct.	+2·73	+0·98	+0·80	+0·29	−0·24	45·0
Nov.	+4·41	+2·04	+1·72	+1·27	+0·05	36·5
Dec.	+3·32	+1·74	+1·18	+1·33	+0·33	33·2
1890.						
Jan.	+2·31	+0·95	+0·59	+0·63	+0·09	42·1
Feb.	+2·69	+1·26	+0·84	+0·51	+0·11	36·2
Mar.	+2·90	+2·00	+1·34	+1·45	+0·20	40·9
Apr.	+3·72	+2·12	+1·41	+1·00	+0·47	40·2
May	+3·45	+1·67	+0·97	+0·61	+0·18	49·6
June	+3·44	+1·17	+0·81	+0·22	+0·09	54·7
July	+2·88	+1·17	+0·87	+0·66	+0·31	56·0
Aug.	+2·95	+1·23	+0·92	+0·53	+0·01	56·7
Sept.	+2·91	+1·61	+1·19	+0·45	+0·18	56·1
Oct.	+3·30	+1·46	+1·11	+0·51	−0·13	44·5
Nov.	+2·96	+1·86	+1·10	+0·95	−0·02	40·8
Dec.	+3·35	+3·40	+1·85	+1·15	+0·65	28·3
1891.						
Jan.	+2·91	+1·81	+1·57	+0·96	+0·47	33·1
Feb.	+3·67	+2·77	+1·83	+1·40	+0·60	37·0
Mar.	+4·00	+1·10	+1·20	+0·50	+0·70	41·8

Taking the months of the same name together, and weighting according to the number of observations, we get the following results for the annual inequality, where the time of year, and not the actual temperature, is now taken as the independent variable :—

Table IX.

	Mean Excess over F of					Mean Reading of F
	I	M	N	S	E	
	°	°	°	°	°	°
Jan.	+2·35	+1·23	+0·91	+0·77	+0·27	37·2
Feb.	+2·51	+1·27	+0·91	+0·41	+0·35	36·4
Mar.	+2·57	+1·77	+1·18	+1·17	+0·13	40·1
Apr.	+3·09	+1·76	+1·37	+0·81	+0·23	43·9
May	+2·93	+1·38	+0·80	+0·59	−0·02	50·1
June	+2·48	+0·78	+0·68	+0·10	−0·13	56·0
July	+2·60	+0·97	+0·82	+0·43	+0·06	56·1
Aug.	+2·67	+1·16	+0·90	+0·41	−0·33	57·2
Sept.	+2·79	+1·35	+0·85	+0·67	−0·11	53·8
Oct.	+2·73	+1·09	+0·86	+0·38	−0·28	45·4
Nov.	+3·32	+1·58	+1·17	+0·93	+0·07	40·9
Dec.	+2·97	+1·59	+1·09	+1·14	+0·13	36·0

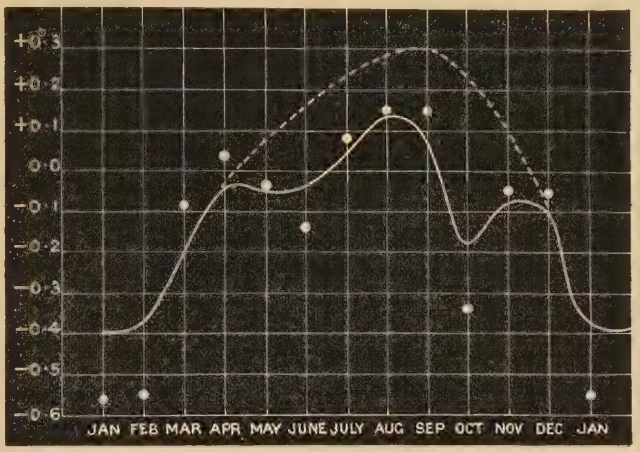
The effect of the transformation is remarkable. The mean standard external temperature in the last column shows an annual inequality with a range of some 20°, but the interior thermometers do not respond to this as we might have expected from the previous discussion.

The following table shows the mean monthly excess of these quantities over the theoretical expressions on p. 13, the two series having been combined with proper weights:—

	I	M	N	S	E	Mean
	°	°	°	°	°	°
Jan.	−1·07	−0·88	−0·56	−0·25	−0·12	−0·58
Feb.	−0·90	−0·91	−0·56	−0·45	0·00	−0·56
Mar.	−0·27	−0·04	−0·21	+0·18	−0·13	−0·09
Apr.	+0·13	+0·01	+0·09	−0·02	+0·01	+0·04
May	+0·39	−0·13	−0·19	−0·10	−0·10	−0·03
June	+0·07	−0·36	−0·11	−0·30	+0·01	−0·14
July	+0·44	−0·07	−0·02	−0·06	+0·17	+0·09
Aug.	+0·59	+0·13	+0·16	−0·05	−0·12	+0·14
Sept.	+0·43	+0·14	+0·00	+0·22	−0·02	+0·15
Oct.	−0·13	−0·53	+0·29	−0·36	−0·33	−0·33
Nov.	+0·22	−0·20	−0·07	+0·09	−0·17	−0·03
Dec.	−0·30	+0·01	−0·17	+0·11	−0·02	−0·07

Now, a simple annual wave will not adequately represent any of these curves. There are two well-marked dips in May and October, giving the wave the appearance of being "squashed" in the middle by a secondary cause, as indicated by the continuous wave suggested by a dotted line in the diagram. I

venture to interpret this wave as follows:—If an interior thermometer were disturbed by sources of heat *of constant temperature* alone, such as the observer's body and the gas flames, its excess over the standard thermometer would probably be simply a function of the external temperature. Consider, for



instance, the observer's body alone. When the external temperature was that of the body, both thermometers should agree; but the colder the weather the larger would be the influence of the body in raising the reading of the interior thermometer.

But the disturbance arising from the walls of the room is different. Their sub-permanent temperature is higher in summer than in winter, and hence, on a day in summer, when the external temperature was (say) 45°, they would raise the interior thermometer more than on a day in winter when the external temperature was also 45°. Thus an expression for the reading of an interior thermometer as a function of external temperature alone is not sufficient. We must add a term following the temperature of the walls of the room. And it seems to me that the "squashing" of the above curve affords evidence that the influence of the walls is a *vera causa*. I ascribe this break of continuity to the fact that fires are lit in the adjoining buildings during the winter months, but not used from about May to October. If they were retained the sub-permanent temperature of the walls would make a simple sweep of annual period, but the rise is checked by losing the fires, as is the fall by recovering them. This is, however, at present, mere conjecture.

The fact remains that the readings of the interior thermometers are functions of the external temperature and of the time of year combined. This is exhibited more directly in the following tables of double entry:—

Month.	20° to 25°	25° to 30°	30° to 35°	35° to 40°	40° to 45°	45° to 50°	50° to 55°	55° to 60°	60° to 65°	65° to 70°
					Excess of Thermometer I over F.					
Jan.	+4°2	+3°2	+3°3	+2°4	+2°2	+0°8	−0°2	...	...	...
Feb.	...	+3·2	+3·5	+2·6	+1·7	+0·7	...	...	...	...
Mar.	+4·6	+5·3	+2·1	+2·7	+3·1	+1·4	+1·5	...	...	...
Apr.	...	+5 6	+4·1	+4·1	+3·4	+2·2	+0·8	...	...	...
May	...	...	...	+4·7	+4·3	+3·7	+2 9	+2·0	+1·2	...
June	...	...	...	...	...	+3·8	+3·2	+2·4	+2·1	+0·9
July	...	...	...	...	...	+5 3	+3·0	+2·9	+1·8	...
Aug.	...	...	...	...	...	+4·4	+3·7	+3 2	+1·4	+1·8
Sept.	...	...	...	+6 2	+4·8	+3·7	+3·0	+2·4	+2·9	−0·1
Oct.	...	...	+4·5	+3·5	+3·2	+2·9	+2·5	+0·7	...	...
Nov.	+4·0	+6·1	+4·9	+4·1	+3 0	+2·5	+1·1	...	...	...
Dec.	+5·1	+4·5	+3·2	+3·0	+3·5	+2·7	+1·1	...	...	...
					Excess of Thermometer E over F.					
Jan.	+0°9	+0°6	+0°2	+0°2	0°0	−0°3	−0°5	...	...	...
Feb.	...	+0·8	+0·3	+0·2	+0·1	−0·1	...	...	...	...
Mar.	+1·1	−0·8	+0·6	−0 2	0·0	0·0	−0 4	...	...	...
Apr.	...	+0·9	+0·7	+0·5	+0·1	−0·2	−0·5	...	...	...
May	...	...	...	−0·3	+0·3	0·0	−0·1	0·0	−0·5	...
June	...	...	...	...	...	−0·1	−0·2	−0·3	−0·4	+0·2
July	...	...	...	...	...	+1·1	0·0	+0·2	−0·2	...
Aug.	...	...	...	...	...	−0·3	−0·1	−0·2	−1 0	−1·0
Sept.	...	...	...	−0·2	+0·2	−0·4	−0·2	+0·1	−0·3	−0·7
Oct.	...	...	+0·2	−0·5	−0·6	−0·2	−0·2	−0·6	...	...
Nov.	+0·6	+0·9	0 0	+0·3	+0·1	−0·4	−0·6	...	...	...
Dec.	+1·4	+0·5	−0·2	+0·1	+0·1	−0·4	−0·7	...	...	...
					Excess of Thermometer N over F.					
Jan.	+2°0	+2°5	+1°1	+0°7	+0°4	+0°2	−0°4	...	...	...
Feb.	...	+1·0	+1·4	+0·7	+0·2	+0 2	...	...	...	...
Mar.	+3·1	+1·5	+0·9	+0 9	+1·0	+0 3	+0·2	...	...	...
Apr.	...	+2·9	+2·2	+1·5	+1·0	+0 7	+0·3	...	...	...
May	...	...	...	+1·1	+1·4	+0·9	+0·7	+0·4	+0·2	...
June	...	...	...	...	...	+0·6	+0·9	+0·5	+0·1	+0·5
July	...	...	...	...	...	+1·5	+1·0	+0·8	+0·3	...
Aug.	...	...	...	...	...	+1·6	+1·1	+1·0	0·0	+0·9
Sept.	...	...	...	+1 6	+1·3	+1·3	+0·6	+0·5	+1·5	−0 5
Oct.	...	...	+2·6	+0·6	+0·9	+0·8	+0·3	+0·1	...	...
Nov.	+0·8	+1·3	+1 9	+1·4	+1·0	+0·6	0·0	...	...	...
Dec.	+3·0	+1·5	+0·9	+1·1	+1·3	+0·4	−0·1	...	...	...

Month.	20° to 25°	25° to 30°	30° to 35°	35° to 40°	40° to 45°	45° to 50°	50° to 55°	55° to 60°	60° to 65°	65° to 70°
					Excess of Thermometer M over F.					
Jan.	+3°0	+1°7	+1°5	+0°9	+0°7	+0°5	0°0	...	...	...
Feb.	...	+1·1	+1·9	+1·0	+0·4	+0·3	...	...	...	...
Mar.	+4·3	+2·9	+1·0	+1·3	+1·5	+0·5	+0·6	...	...	...
Apr.	...	+4·3	+2·8	+2·3	+1·4	+1·1	+0·1	...	...	...
May	...	...	...	+2·2	+2·2	+1·5	+0·9	+0·6	+0·8	...
June	...	...	...	...	...	+1·5	+0·7	+0·5	+0·5	+0·3
July	...	...	...	...	...	+2·6	+1·0	+0·8	+0·4	...
Aug.	...	...	...	...	...	+1·7	+1·5	+1·3	+0·2	+1·1
Sept.	...	...	...	+5·4	+1·0	+1·7	+0·7	+0·7	+2·1	+0·1
Oct.	...	...	+2·2	+1·5	+0·9	+1·0	+0·5	+0·2	...	...
Nov.	+1·7	+2·9	+1·9	+2·1	+1·6	+0·7	+0·5	...	...	...
Dec.	+4·9	+3·0	+1·9	+1·3	+1·4	+0·7	+0·2	...	...	...
					Excess of Thermometer S over F.					
Jan.	+1°0	+0°7	+1°0	+0°6	+0°5	+0°3	−0°1	...	...	...
Feb.	...	+0·5	+0·7	+0·5	+0·1	+0·1	...	...	...	...
Mar.	+2·7	+0·1	+0·9	+0·7	+0·8	+0·8	+0·6	...	...	...
Apr.	...	+2·3	+1·2	+1·0	+0·6	+0·4	−0·1	...	...	...
May	...	...	...	+0·4	+1·1	+0·6	+0·2	+0·1	+1·0	...
June	...	...	...	...	...	+0·1	+0·2	0·0	−0·5	−0·2
July	...	...	...	...	...	+2·1	+0·5	+0·3	−0·2	...
Aug.	...	...	...	...	...	+1·1	+0·6	+0·6	+0·5	+0·5
Sept.	...	...	...	+3·0	+1·0	+0·9	+0·5	+0·2	+0·6	−0·3
Oct.	...	...	+0·5	+0·1	+0·1	+0·5	0·0	+0·2	...	...
Nov.	+0·6	+1·6	+1·7	+1·0	+0·9	+0·4	+0·4	...	...	...
Dec.	+1·4	+1·0	+0·8	+1·4	+1·5	+0·6	+0·3	...	...	...

The effect of the seasons is best seen in the column 45° to 50° common to all the months. The gradual diminution with rise of temperature is seen in any horizontal row.

This paper was already in type when Mr. Ellis suggested to me a concise method of dealing with these tables. He remarked that the reading of any thermometer appeared to be approximately a function of the *difference of the external temperature from the average*. The excess of any thermometer is, for instance, about the same in January for temperatures of 28°, 38°, and 48° as in July for temperatures of 50°, 60°, and 70°; the average temperature in January for the period under consideration being 38°·3, and in July 59°·5. I therefore analysed the tables afresh from this point of view. I was at first in doubt whether to select the average temperature for the approximate hour of observation (say, 9 P.M.) or the general average throughout the day as the basis; but a few figures show at once that

this point is not important. The two systems of averages for the period in question are shown in the following table:—

Month.	General Average.	Average at 9 P.M.	Month.	General Average.	Average at 9 P.M.
Jan.	38°·3	38°·4	July	59°·5	57°·6
Feb.	37·8	37·4	Aug.	59·6	57·2
Mar.	41·4	40·4	Sept.	57·1	54·8
Apr.	44·9	43·1	Oct.	48·1	46·7
May	54·7	52·0	Nov.	45·1	44·4
June	59·3	57·2	Dec.	36·1	35·7

The greatest difference between the two systems is 2°·7 in May, corresponding to a difference of about 0°·3 in the excess I—F. It is, therefore, almost immaterial which system we select; but as the influence of the walls (whose temperature would be more nearly related to the general average than to the average at a particular hour) has been suggested, it seems preferable to take the general average as our basis.

Assuming, then, that the excess of any thermometer over F may be represented by the expression

$$a - b \text{ (excess of F above average)},$$

I find the following approximate values for a and b:—

	I−F		N−F		M−F		S−F		E−F	
	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)
Jan.	2°·1	0·13	0°·8	·09	1°·1	·08	0°·5	·07	+0°·1	·04
Feb.	2·3	·14	0·7	·07	0·9	·08	·4	·03	+0·3	·03
Mar.	2·6	·10	0·8	·07	1·3	·09	·8	·03	−0·1	·02
Apr.	2·6	·16	0·9	·10	1·3	·15	·5	·08	−0·1	·06
May	2·3	·15	0·4	·05	0·7	·10	·5	·02	−0·2	·01
June	2·2	·13	0·4	·03	0·6	·05	−·1	·03	−0·1	·00
July	2·5	·18	0·5	·07	0·6	·12	·0	·13	0 0	·06
Aug.	2·6	·16	0·8	·06	0·8	·06	·6	·02	−0·6	·05
Sept.	2·5	·14	0·5	·05	1·2	·09	·5	·07	−0·3	·01
Oct.	2·6	·11	0·7	·07	0 9	·06	·2	·00	−0 3	·00
Nov.	2·6	·14	0 7	·04	1·1	·06	·6	·04	−0 2	·04
Dec.	3·4	·09	1·2	·06	2·0	·12	1·0	·01	+0 2	·05

There is obviously a very fair accordance between these numbers. If we divide the year into two periods of six months, November—April and May—October, the mean values of the above quantities are—

	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)
Winter	2°·6	·13	0°·8	·07	1°·4	·10	0°·6	·04	0°0	·04
Summer	2 5	·15	0·6	·06	0 8	·08	0·3	·05	−0·3	·02

Now, according to the views already expressed in this paper, we may regard the constant (a) in each case as resulting from disturbance by the gas-flames and the observer's body. When the temperature is just the average the walls will be nearly at the temperature of the external air, and but for the gas-flames and the observer's body the interior of the room should be so too; but these disturbing causes raise the temperature of any given point in the room by a nearly constant quantity throughout the year. The quantity is a little greater in winter than in summer, as we should naturally expect; close to the instrument (thermometer I) it is about 0°·1 greater in winter out of 2°·5; at the boundary of the shutter opening (thermometers N, M, S) it is about 0°·9 in winter and 0°·6 in summer. The difference between winter and summer is 0°·3 also for thermometer E; but it is not easy to explain the negative value for E, which is, however, possibly accidental.

The term with coefficient (b) is to be considered as due to the walls, which tend to lower the internal temperature when the external is above the average, and to raise it when the external is below. Close to the instrument (thermometer I) the influence of the walls annuls that of the gas-flames when the external temperature is about 16° above the average, and doubles it when about 16° below. In the shutter-opening (thermometers N, M, S) the annulling is effected at 11° above, and the doubling at 11° below. We are thus led to the following important conclusion:—

A phenomenon which depends purely upon the distribution of temperature inside the transit-circle room should disappear when the external temperature is about 13° *above the average, and be doubled when the temperature is about* 13° *below the average.*

Two minor points have been investigated—(A) the change in reading as the shutters have been left open for a longer time; and (B) the influence of the direction of the wind.

(A) As stated above, it was directed that the thermometers should be read only when the shutters had been thrown open at least fifteen minutes; and the time since opening was to be recorded. The results were arranged according to these recorded times, and means taken, as in the following table:—

Time since Shutters were Opened.

Excess over Theoretical Value of	½ hr. or less	½ hr. to 1 hr.	1 hr. to 1½ hr.	1½ hr. to 2 hrs.	2 hrs. to 3 hrs.	3 hrs. to 4 hrs.	4 hrs. to 5 hrs.	More than 5 hrs.
	°	°	°	°	°	°	°	°
I−F	−1·27	−0·18	−0·14	+0·09	+0·02	−0·02	+0·10	+0·56
N−F	−0·62	0·00	+0·01	−0·09	−0·03	+0·39	+0·19	+0·19
N−F	−0·67	−0·09	−0·22	−0·03	0·00	+0·66	+0·28	+0·51
S−F	−0·17	−0·15	−0·21	−0·01	−0·16	+0·20	+0·01	+0·55
E−F	−0·06	−0·04	−0·14	+0·05	+0·08	−0·10	+0·02	+0·01
Mean	−0·56	−0·09	−0·16	0·00	−0·02	+0·23	+0·12	+0·36

The general result is, that although a slow change goes on for a considerable time in the distribution of temperature in the room, it is comparatively rapid for the first hour. But it is remarkable that this change should be a *rise* of temperature—*i.e.* when shutters are closed the room is below the normal temperature! The explanation is doubtless to be found in the fact that when the observer opens the shutters he also turns up various gas jets.

If the results are analysed according to the excess or defect of temperature from the average, it is found that the rise of internal temperature is much more rapid when the external temperature is *above* the average.

(B) The observations were divided into eight groups, according to the direction of the wind as recorded in the Meteorological Department, the eight major points N., N.E., E., S.E., S., &c. being selected as a sufficiently close approximation. There is, of course, much more S.W. wind than any other. The results are shown in the following table :—

Excess above Theoretical Value of	Direction of Wind. N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
	°	°	°	°	°	°	°	°
I−F	+0·38	+0·50	+0·23	+0·10	−0·15	−0·32	−0·41	−0·26
N−F	+0·54	+0·01	−0·16	−0·27	+0·06	−0·04	−0·09	+0·02
M−F	+0·53	+0·44	+0·34	+0·01	−0·14	−0·32	−0·43	+0·01
S−F	+0·49	−0·08	+0·08	−0·37	−0·29	−0·10	−0·18	+0·19
E−F	+0·45	+0·15	+0·01	−0·30	−0·23	−0·17	−0·04	+0·63
Mean	+0·48	+0·20	+0·10	−0·17	−0·15	−0·19	−0·23	+0·12

The general result is, that the interior temperature is higher with easterly winds than with westerly.

General Conclusions.

The distribution of temperature in the transit-circle room must have a sensible influence on zenith-distance observations. It is not, however, proposed to consider the manner of this disturbance here; it is deemed advisable to limit the scope of this paper to a statement of the results obtained by the reading of six thermometers placed at different points of the room during three years, on nights when astronomical observations were possible. The general conclusions are as follows:—

(1) The excess of interior temperature over exterior is larger in cold weather than in warm a linear relation between this excess and the external temperature is a fair approximation for a thermometer hung at any point of the room.

(2) This linear relation is disturbed by the seasons. In all months of the year an external temperature of (say) 45° is liable

to occur in the evening; but the readings of an interior thermometer would be higher in summer than in winter on such an evening.

(3) This is possibly due to the influence of the walls of the room, whose sub-permanent temperature is higher in summer than in winter. Circumstantial evidence of this influence is perhaps afforded by a break of continuity when fires are lighted or given up in the adjacent buildings.

(4) Regarding the matter from another point of view, the internal temperature depends simply upon the difference of external temperature from the average.

(5) When the shutters of the room are thrown open a readjustment of temperature proceeds somewhat rapidly for about an hour, and also afterwards, but more slowly. But it is a *rise* of temperature, and is probably due to the turning up of the gas simultaneously with the opening of the shutters.

(6) The interior temperature is generally higher with easterly winds than with westerly.

The Orbit of τ Cygni. By S. W. Burnham, M.A.

The companion to this star was discovered by Alvan G. Clark in 1874, October, with the 26-inch object glass, which was subsequently mounted at the McCormick Observatory. At this time the new pair was not difficult, and it was measured on many nights in the few years following by Dembowski with an instrument of about seven inches aperture. His observations were the first to show that the small star was in motion, and they continued long enough to prove a change of about 30° in angle, with some diminution of the distance. It was soon evident that this was orbital motion. The large star was known to have a large proper motion, amounting annually to $0''\cdot484$ in the direction of $17°\cdot3$, and the measures showed that this belonged to the small star as well, and that they must form a physical system. The companion was also measured by other observers from time to time, but very little was done for some years following 1880. It had become a much closer and more difficult object, and like all similar pairs it was neglected by many observers with instruments sufficiently powerful to measure it properly.

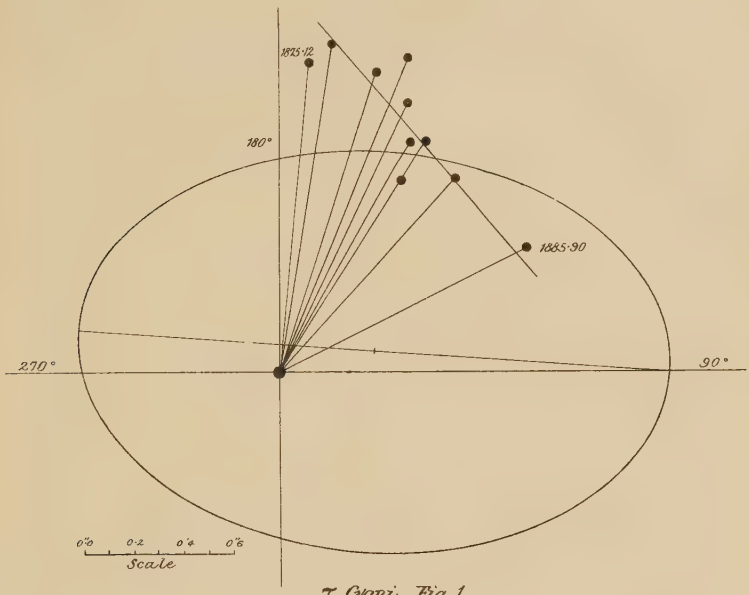
When my work in this line commenced at the Lick Observatory, I placed this pair on the working list, and observed it regularly every year as long as I remained there. By this time the change in distance of the components had made it a rather difficult pair with the 36-inch, except under very favourable conditions.

Gore in 1886, using the measures down to 1885, computed a provisional orbit of this pair, and found a period of 53·87 years (A. N. 2749). Some of the measures were discordant, and the

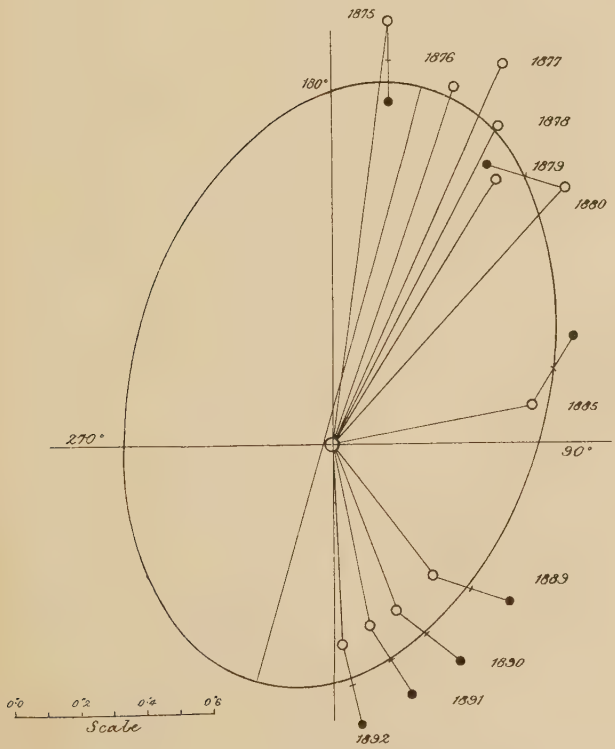
arc was too small to give any very good result. The apparent orbit found at that time is shown in Fig. 1, and all the measures as used in the computation are accurately laid down to scale. It will be observed that the distance errors are very large, and that almost any ellipse would represent the positions equally well. In fact, a straight line will do this as a whole better than anything else. When the later measures at Mount Hamilton were made, it was clear that the apparent orbit must be represented by a very different ellipse, and therefore special attention was given to measuring the companion with all possible care. The arc passed over is now nearly 180°, and with a sufficient number of reliable measures a good orbit should be made. The following are all the published measures of this pair, arranged in chronological order:—

1874·89	162°·6	1″·11	2*n*	Newcomb
1875·12	174·5	1·24	2*n*	Dembowski
1875·69	170·5	1·32	3*n*	Dembowski
1876·79	161·5	1·24	2*n*	Dembowski
1876·83	166·9	1·62	2*n*	Waldo
1876·90	160·2	1·03	2*n*	Hall
1877·70	155·3	1·26	8*n*	Dembowski
1878·41	150·0	1·06	1*n*	Burnham
1878·54	147·5	1·09	3*n*	Dembowski
1878·76	158·8	1·09	2*n*	Hall
1879·50	148·3	0·90	2*n*	Burnham
1879·75	147·3	0·98	6*n*	Hall
1880·77	137·4	1·04	1*n*	Frisby
1883·88	159·2	...	3*n*	Seabroke
1885·52	116·3	1·08	3*n*	Tarrant
1885·73	100·7	0·62	1*n*	Hall
1886·78	80· ±	0·5 ±	1*n*	Hough
1887·76	56·4	0·4 ±	1*n*	Hough
1889·49	36·5	0·50	4*n*	Burnham
1890·54	20·5	0·54	3*n*	Burnham
1891·49	12·4	0·61	3*n*	Burnham
1891·69	9·3	0·52	3*n*	Hall
1892·40	2·3	0·61	3*n*	Burnham

It is obvious that some of these measures are of no value in an investigation of the relative motion, and that if any trustworthy conclusion is reached, it must be by rejecting doubtful and incomplete measures, and combining those made on a proper number of nights and by the most experienced observers. There-



τ Cygni. Fig. 1.



τ Cygni. Fig. 2.

Spottiswoode & Co. Lith. London.

fore, as a preliminary step to laying down the positions to scale, I have selected the following:—

1875·46	172°·1	1″·29	5*n*	De.
1876·85	160·8	1·14	4*n*	De.–Hl.
1877·70	155·3	1·26	8*n*	De.
1878 57	152·1	1·08	6*n*	De.–Hl.–*β*
1879·62	147 8	0·94	8*n*	Hl.–*β*
1880·77	137·4	1·04	1*n*	F.
1885·73	100·7	0 62	1*n*	Hl.
1889·49	36·5	0·50	4*n*	*β*
1890·54	20·5	0·54	3*n*	*β*
1891·59	10·8	0·56	6*n*	Hl.–*β*
1892·40	2·3	0·61	3*n*	*β*

These observations are shown on Fig. 2, which is a photographic reduction of the large drawing, by the white circles connected by radial lines with the central star. An examination of these positions shows that the angular motion from 1875 to 1880 is too rapid when compared with the observed places 1889 to 1892; or the motion for the latter interval should be increased to make the areas described proportional to the times. The measures in the first interval are by the most experienced observers with the micrometer, and they are means of a sufficient number of nights to give presumably good results both in angle and distance. The last series of measures were made with the best telescope for the purpose in the world. I used every precaution to get good measures. They were made with a power of at least 1500, with favourable atmospheric conditions, and are consistent with each other. If we assume that the errors are uniformly distributed, which in cases of this kind is certainly not likely to be the fact, and that the angular motion and the distances are too large for the first interval, and correspondingly too small in the second, we find that the apparent ellipse which will satisfy the times requires corrections to the measures which are apparently inadmissible, and that it is necessary to wait for further measures in order to determine where the truth is.

There always remains in an example like this, where observations have some inconsistency when considered together, another method of treating them, which might be termed the heroic treatment, by the introduction of another star which shall account for and explain the apparent anomalies. It is always easy to do this, since one is not hampered by any restrictions, and can assume anything to supply the apparent deficiency shown by the actual observations.

It is obvious from an inspection of the observed positions shown on the diagram what the general character of the supposed

invisible star must be to harmonise the observations. Let us assume that the Clark companion is attended by a "dark" sun of equal mass, the two revolving about the common centre of gravity in an orbit whose plane is at right angles to the line of sight. For the revolution of these stars we may take 17·6 years, since this will answer the purpose as well as any other, and further assume that their apparent distance is a quarter of a second, the position angle of the invisible star being zero at the date of the first measures, and the motion retrograde. Then for the dates of the respective measures the angles are as follows:—

1875·46	P = 360°·0	1885·73	P = 150°·0
1876·85	331·6	1889·49	73·1
1877·70	314·1	1890·54	51·6
1878·57	296·4	1891·59	30·2
1879·62	274·9	1892·40	13·6
1880·77	251·4		

The positions of the dark star at the several dates are indicated on the diagram by dark circles connected by straight lines with the observed positions of the real star. These are omitted for the observations between 1875 and 1880 to avoid confusing the diagram. The distance between the two stars is 0″·25, and of course the centre of gravity is at the middle of the line joining the two circles.

The next step was to draw an ellipse as accurately as possible through the centre of gravity at the various epochs, and after several trials the ellipse shown in the diagram, Fig. 2, was made. When this was examined, and the areas described by the line drawn from the principal star to the centre of gravity of B and C compared with the corresponding times, a very satisfactory agreement was found. The following are the errors of the angles and distances:—

1875·46	0°·0	−0″·07	1885·73	−8°·0	0″·00
1876·85	+2·5	+0·08	1889·49	−2·7	0·00
1877·70	+2·3	−0·06	1890·54	−1·1	−0·01
1878·57	−0·4	+0·10	1891·59	+3·0	0·00
1879·62	−4·0	+0·18	1892·40	−3·1	−0·03
1880·77	0·0	0·00			

Doubtless these errors could have been differently and possibly better distributed, but the variations are small, and will compare favourably with those of most of the computed orbits where the measures are easily made. This harmonises all the measures in angle and distance, and whatever the probabilities may be as to the existence of a disturbing third body, they are at least as strong in this case as in any other instance where a

similar assumption has been made. This ellipse also represents the observed positions of the known companion, leaving the third star out of the question, as well as any which can be drawn at this time, but it will be seen that the errors of the measures are very much larger in angle and distance, and certainly larger than they should be in first-class observations.

The following elements of the orbit are found from this ellipse :—

$$P = 36{\cdot}5 \text{ years}$$
$$T = 1893{\cdot}1$$
$$e = 0{\cdot}24$$

An ephemeris for the visible companion star is easily made from the apparent orbit. The following are the angles and distances of the companion, according to this theory, as they should appear from the measures at these times :—

1893·40	350°·0	0″·62
1894·40	341·6	0·64
1895·40	332·3	0·64

Before treating this matter very seriously, I would suggest the propriety of waiting until additional observations are made. It may be that the third star can be dispensed with. In any case this pair should be carefully observed each year. A few good measures will be of more value than any amount of speculation. It is evident that the companion can be measured in every part of the orbit. In double star matters we can afford to wait longer for theories than for results with the micrometer. Nor will it do to place too much reliance upon residuals, and the apparent agreement of observations with a proposed theory, since it must be a very poor theory which will not accurately fit the known facts it was intended to explain. It is the subsequent observations which are dangerous to a preconceived theory.

Chicago :
April 20.

Photograph of the Cluster M. 35 *Geminorum.*

By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster M. 35 *Geminorum*, R.A. $6^h\ 2^m$, Decl. 24°·21′ north, was taken on the 7th February, 1893, with exposure of the plate during 66 minutes. It is No. 1360 in the *General Catalogue*, and is described by Sir J. Herschel as very large; considerably rich; pretty compressed; stars 9th to 16th mag., about 100 stars in one field.

Lord Rosse in his *Observations of Nebulæ and Clusters of Stars*, p. 52, describes the cluster as magnificent, in a rich field, and he estimated 300 stars in the Finder-field of 26 minutes of arc, many of which are not below 11th mag.

On the photograph, now presented, I counted 620 stars in the cluster, within a circle of 26 minutes of arc, in diameter, many of which have close faint apparent *comites*, and some are triple stars. The stars in the region around the cluster are numerous and mostly faint.

The cluster H VI. 17, *General Catalogue*, No. 1351, is shown on the photograph at 1m. 24s. R.A. and 0°·14′·5 Decl. s.p. the cluster M. 35. It is described by Sir J. Herschel as pretty small; much compressed; very rich; irregular triangle of stars extremely small, which description agrees well with the photograph.

Photograph of the Cluster M. 36 Aurigæ.
By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster M. 36 *Aurigæ*, R.A. $5^h\ 27^m$, Decl. 34°·6′ north was taken on the 8th February, 1893, with exposure of the plate during 90 minutes. It is No. 1166 in the *General Catalogue*, and is described by Sir J. Herschel as bright, very large; very rich; little compressed; stars 9th to 11th mag. and scattered.

Lord Rosse in his *Observations of Nebulæ and Clusters of Stars*, p. 48, describes it as a coarse cluster of large stars; fine double star in it.

The photograph now presented and enlarged to the scale of 24 seconds of arc to one millimetre agrees generally with the descriptions cited, but there are some stars in the cluster apparently double, and triple; there is also at least one multiple star. There is no nebulosity in the cluster, and the stars are shown to about the 16th mag. This region of the sky is richly covered with stars which by their configurations will in the future afford the astronomer an important field for correlation and study by aid of photographic methods.

Photograph of the Cluster M. 37 Aurigæ.
By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster M. 37 *Aurigæ*, R.A. $5^h\ 45^m$, Decl. 32°·31′ north was taken on the 8th February, 1893, with exposure of the plate during 90 minutes. It is No. 1295 in the *General Catalogue*, and is described by Sir J. Herschel as rich; pretty compressed in the middle; stars large and small.

Lord Rosse in his *Observations of Nebulæ and Clusters of Stars* calls attention to wonderful loops and curved lines of stars.

By the photograph now presented and enlarged to the scale of 24 seconds of arc to one millimetre, the descriptions cited are confirmed, and some of the stars in the cluster appear to be double, triple, and multiple, and the region around is much crowded with stars, each one of which is now shown, to a scale, in true relative position and magnitude down to about the 16th. The configurations of the stars are, in the words of Lord Rosse, wonderful.

Photograph of the Cluster M. 50 Monocerotis.
By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster M. 50 *Monocerotis*, R.A. $6^h\ 58^m$, Decl. $8°{\cdot}11'$ south was taken on the 10th March, 1893, with exposure of the plate during 90 minutes. It is No. 1483 in the *General Catalogue*, and is described by Sir J. Herschel as a remarkable cluster; very large; rich; pretty compressed; elongated; stars 12th to 16th mag.

Lord Rosse in his *Observations of Nebulæ and Clusters of Stars*, p. 55, 1852 to 1876, describes it as a coarse cluster; very large; straggling; irregularly round; spiral arrangement; extending about $15'$ n. s. and $10'$ p. f.; stars 12th to 15th mag.

The photograph shows the stars to be generally brighter and less numerous than those in the clusters M. 35 *Geminorum* and M. 36 and 37 *Aurigæ*, but it presents the same characteristics of apparent *comites* and double stars as those clusters. The photograph does not suggest the spiral arrangement referred to by Lord Rosse, and the stars are shown to about 16th mag.

Negatives of Jupiter, made with the Great Telescope of the Lick Observatory during the Opposition of 1892–3. By Edward S. Holden, W. W. Campbell, and A. L. Colton.

We have the honour to present to the Royal Astronomical Society, in the name of the Lick Observatory, a series of negatives of *Jupiter*, made with the great telescope during the opposition of 1892–3, in continuation of similar work. The following memoranda should accompany them:—

The negatives were all made on specially fast plates, prepared for us by the Cramer Company, 8×10 inches in size. There are usually nine images of the planet on each plate. The enlargements were directly made in the telescope, using the full aperture of 33 inches, by means of a capital amplifying lens made for the Observatory at the cost of the Smithsonian Institution, by Mr. Brashear, from calculations by Professor

C. S. Hastings, of Yale University. This lens is used so as to give a direct enlargement of about five diameters. The images under good circumstances are all that can be desired. It must be remembered, however, that the negatives are affected by the wind blowing on the telescope (and by other accidental disturbances), as if they were taken in the principal focus of a telescope 237 feet long.

Most of the exposures have been made by the three observers working together. All the plates have been developed by Mr. Colton. At first hydroquinone was used as a developer, but a pyro-developer was found to produce sharper contrasts. An exposure of two seconds is ample for the general features of the planet. Six seconds gives the satellites so that they are measurable. Each plate is marked (in Indian ink, which is presumed to be permanent) with sufficient data. The amplifying lens is set at 2·87 of its scale; the negative plate at 1·5 of the focusing scale. The times are Pacific standard times=G.M.T.−8 hours. Several negatives were made on each night, and the best have been selected for preservation at the Lick Observatory. All the others were called "duplicates," and as full a set of these as possible has been made up for presentation to the Royal Astronomical Society, irrespective of the excellence of the individual pictures, for reasons which are given in the *Monthly Notices*, vol. lii. p. 500. These negatives have been submitted to Mr. A. Stanley Williams, F.R.A.S., for examination and copying; and we take this opportunity of acknowledging his most welcome aid in the matter of the investigation and discussion of the plates.

List of Negatives of Jupiter presented to the Royal Astronomical Society.

Date.	Number of Images on the Plate.	Approximate P.S.T.	Remarks.
1892.		h m	
Oct. 20	9	8 16	No wind, but stars unsteady.
20	9	11 41	„ „
20	9	13 24	„ „
24	9	7 27	Shadow of I. on disc.
24	9	8 54	Shadows of I. and II. on disc.
24	9	10 15	
24	9	11 34	Through thick haze.
24	9	12 41	„ „
24	9	14 13	
Nov. 10	9	7 17	
10	9	9 3	
10	9	10 26	
10	9	11 42	
10	9	13 5	

Date. 1893.	Number of Images on the Plate.	Approximate P.S.T. h m	Remarks.
Jan. 17	9	7 53	Stars unsteady. Shadow of I. on disc.
18	9	6 2	
18	9	7 58	Circumstances rather poor.
18	5	8 57	Planet low.

Mount Hamilton :
1893 *January* 19.

Note on the Lick Photographs of Jupiter, 1892–3.
By A. Stanley Williams.

The series of original negatives of *Jupiter* which has just been presented to the Society by the Lick Observatory is a remarkably fine one, and should form a valuable addition to the Society's collection of photographs. The following notes may be of interest as supplementing to some extent the paper by Messrs. Holden, Campbell, and Colton, read at the May meeting of the Society.

The method employed in taking these negatives has been considerably improved upon. There are now nine separate images of the planet upon each plate, and the times of the beginnings and endings of all the exposures are exactly recorded. It will, therefore, be possible to measure the positions of markings with great accuracy and satisfaction. From some experiments that I have been making in this direction, I think that measures made upon eight or nine images will be found to give the positions of spots with greater exactness than direct micrometer measures at the telescope.

The photographs themselves are, upon the whole, a great improvement upon those of previous years. The amount of small detail shown in some of them is simply immense, and the sharpness of the images really marvellous. The magnificent enlargement of 1892 Nov. 10, which accompanies the negatives, shows well some of the qualities and capabilities of the photographs. Here we have the equatorial diameter of *Jupiter*, measuring *nearly four inches*, and yet the chief belts and markings are distinct and fairly sharp in outline. Their positions could be measured pretty exactly with a measuring instrument of no greater degree of refinement than a foot rule.

This enlargement is an interesting one in several respects. Amongst other things it shows the two oldest, or longest-known features of the planet, the chief belts of course excepted. The first of these is the great red spot and the neighbouring region. The red spot, as usual, is plainer in the photograph than it was visually in the telescope. The other marking is of a different nature altogether. On the north side of the north

equatorial belt opposite the red spot, but a little to the left of its centre, is a brighter spot, which makes a considerable indentation in the dark north equatorial belt. This spot was first recorded, by Mr. Denning, as long ago as 1885 Jan. 27. In the photograph it is plain enough even when viewed at the normal distance of vision, and it becomes quite glaringly conspicuous if the photograph be held at a distance of about four feet. Now this plainness is a curious thing, for I observed this spot frequently last year, and in the telescope it was *rather a faint spot*, so that relatively to other markings this bright spot was plainer photographically than visually last year; in this respect, therefore, it resembled the red spot, but probably from a different reason. The red spot comes out more distinctly because, on account of its reddish tint, it fails to affect the photographic plate. The bright spot, however, must, I think, have had a greenish or bluish tint, and its light has consequently caused a greater amount of photographic action than would otherwise have been the case. It may be mentioned that some of the other photographs show details in connection with this bright spot, which quite escaped my notice when observing the planet directly, although I paid a good deal of attention to the object last year. The same remark applies likewise to the red spot, and since the latter was so faint in the telescope last year, the fact that it is relatively plainer in the photographs is of great importance.

Many of the negatives in the present collection are good enough to stand enlarging considerably, though not, perhaps, to the extent of the magnificent specimen referred to above. I have been making some experiments in this direction lately, and present to the Society a positive enlarged about two diameters from the negative taken on 1892 October 24, at $12^h\ 42^m\ 28^s$–32^s P.S.T. This enlargement shows much delicate detail in the form of spots, shadings, and other markings, and hence gives some idea of the beauty and capabilities of the original negative. On a mere casual glance I counted as many as thirty-seven or thirty-eight distinct spots, including under this name little projections on the edges of the belts. Most of these spots are plain and definite enough for their positions to be readily measured. An exhaustive examination would, of course, bring out many additional details.

Immersions and Emersions of Jupiter's IV. Satellite. By Rev. S. J. Johnson, M.A.

At the Society's meeting, 1871 May 12, exactly twenty-two years ago, it was stated by Mr. Lassell that the calculations of the phenomena of *Jupiter's* satellites were "made to be used with a telescope of 46 inches focal length, but with the larger telescopes now in use the phenomena are seen at different times." The 46-inch telescope at the period referred to bore an aperture of $2\frac{3}{4}$ inches as a rule. As to the immersions and emersions of the IV. Sat. only, which are the least accurately known beforehand, the following are the differences from *Nautical Almanac* times which I have found with a telescope of this sort, viz., $3\frac{1}{4}$ inches, power employed 180.

It may readily be assumed that first or last visibility as seen with an instrument of this size would be pretty nearly equivalent to the intermediate time between first sight and full brightness in a large telescope, the mode usually adopted for observing these phenomena.

					By Naut. Alm.
			h m s		h m s
1877	Oct. 18	Em.	6 37 30	Haze	6 41 36
1879	Nov. 11	Em.	7 41 18		7 38 50
1884	Mar. 4	Im.	9 49 48		9 48 41
	Mar. 21	Em.	8 20 22		8 22 19
	May 10	Im.	10 2 51		10 2 25
1885	Apr. 27	Em.	8 39 45		8 35 43
1886	Mar. 11	Im.	10 34 57		10 45 2
		Em.	12 39 27		12 28 45
1890	Oct. 11	Im.	9 39 51		9 47 49
1891	Sept. 28	Em.	11 42 53	Haze	11 48 19
	Oct. 15	Em.	6 0 44		5 58 52
	Dec. 21	Em.	6 45 5		6 41 48

Difference from prediction varies from 26^s to $10^m\ 5^s$.

Melplash Vicarage, Bridport:
May 6.

Observations of the Planets Mars and Ceres, made at the Royal Observatory, Greenwich, about the time of their recent conjunction.

(*Communicated by the Astronomer Royal.*)

The observations were made with the East, or Sheepshanks, equatoreal, aperture 6·7 inches, by taking transits over two cross wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power 55.

The observations are corrected for refraction, for parallax, for the error of inclination of the wires, for the motion of the planets, and for the defective illumination of *Mars*.

The two planets and the comparison stars were observed in the same position of the instrument, and the difference in the R.A. and N.P.D. of *Mars* and *Ceres* can be directly inferred from the given measures.

Mars.

Greenwich Mean Solar Time.	Observer.	Planet − ✱ R.A. (corrected).	Planet − ✱ N.P.D. (corrected.)	No. of Comps.	Appt. R.A. of Planet.	Secs. of Tab. R.A.	Appt. Error of Tab. R.A.	Appt. N.P.D. of Planet.	Secs. of Tab. N.P.D.	Appt. Error of Tab. N.P.D.	Comp. Stars.
1893 d h m s		m s	′ ″		h m s	s	s	° ′ ″	″	″	
Apr. 15 8 8 38	A.C.	+ 0 4·85	− 7 41·1	5	4 40 22·93	23·16	+0·23	66 44 4·0	3·9	−0·1	*a*
15 8 10 50	B.	+ 0 5·69	− 7 42·1	5	4 40 23·77	23·42	−0·35	66 44 3·0	3·4	+0·4	*a*
15 8 12 1	A.C.	− 2 56·54	− 3 16·1	2	4 40 23·08	23·56	+0·48	66 44 2·1	3·1	+1·0	*b*
15 8 23 50	B.	− 2 54·69	− 3 17·3	2	4 40 24·93	24·94	+0·01	66 44 0·9	0·4	−0·5	*b*
18 8 56 35	A.C.	+ 1 37·87	− 9 14·4	5	4 48 52·73	53·25	+0·52	66 28 3·5	5·8	+2·3	*d*
18 9 0 15	,,	+ 2 59·75	+ 2 25·3	3	4 48 53·07	53·68	+0·61	66 28 4·1	5·0	+0·9	*c*
18 9 24 18	,,	+ 0 4·87	− 1 50·7	1	...	56·49	...	...	0·0	...	*e*
24 8 50 12	,,	+11 51·22	+ 1 53·6	3	5 5 44·52	44·96	+0·44	66 1 40·5	38·9	−1·6	*f*
24 8 50 12	,,	+ 9 59·53	− 5 54·5	3	5 5 44·64	44·96	+0·32	66 1 37·0	38·9	+1·9	*g*
24 9 4 12	,,	+ 4 11·63	+ 9 8·0	1	5 5 46·31	46·60	+0·29	66 1 36·8	36·7	−0·1	*h*
25 9 17 53	B.	+12 26·99	− 4 1·8	4	5 8 37·11	37·27	+0·16	65 57 50·9	50·0	−0·9	*i*
25 9 17 53	,,	+12 23·51	+ 7 44·0	4	5 8 36·91	37·27	+0·36	65 57 56·7	50·0	−6·7	*j*
25 9 17 53	,,	+ 7 2·48	+ 5 25·1	4	5 8 37·16	37·27	+0·11	65 57 53·9	50·0	−3·9	*h*
25 9 26 3	,,	+ 2 58·68	+ 6 52·0	3	5 8 38·14	38·23	+0·09	65 57 51·2	48·7	−2·5	*k*
25 9 26 3	,,	+ 2 7·25	+14 3·3	3	5 8 38·16	38·23	+0·07	65 57 50·5	48·7	−1·8	*l*
27 9 32 18	H.	+12 42·83	− 1 35·9	3	5 14 17·49	17·35	−0·14	65 50 52·9	53·7	+0·8	*h*

Ceres.

Greenwich Mean Solar Time.	Observer.	Planet − ★ R.A. (corrected.)	Planet − ★ N.P.D. (corrected.)	No. of Comps.	Appt. R.A. of Planet.	Secs. of Tab. R.A.	Appt. Error of Tab. R.A.	Appt. N.P.D. of Planet.	Secs. of Tab. N.P.D.	Appt. Error of Tab. N.P.D.	Comp. Stars.
1893 d h m s		m s	′ ″		h m s	s	s	° ′ ″	″	″	
Apr. 15 8 8 4	A.C.	− 0 29·37	− 3 49·0	5	4 39 48·71	48·31	−0·40	66 47 56·1	59·1	+3·0	*a*
15 8 10 15	B.	− 0 29·22	− 3 51·9	5	4 39 48·86	48·46	−0·40	66 47 53·2	58·7	+5·5	*a*
15 8 11 27	A.C.	− 3 30·93	+ 0 34·8	2	4 39 48·69	48·54	−0·15	66 47 53·0	58·4	+5·4	*b*
15 8 23 14	B.	− 3 30·41	+ 0 33·1	2	4 39 49·21	49·34	+0·13	66 47 51·3	56·9	+5·6	*b*
18 8 52 30	A.C.	− 2 28·06	− 4 16·9	5	4 44 46·80	46·52	−0·28	66 33 1·0	7·2	+6·2	*d*
18 8 56 9	„	− 1 6·35	+ 7 23·2	3	4 44 46·97	46·77	−0·20	66 33 2 0	6·5	+4·5	*c*
18 9 20 11	„	− 4 2·69	+ 3 2·3	1	...	48·43	...	...	1·7	...	*e*
24 8 39 18	„	+ 0 55·46	+ 5 38·0	3	4 54 48·76	48 40	−0 36	66 5 24·9	23·4	−1·5	*f*
24 8 39 18	„	− 0 56 22	− 2 10·1	3	4 54 48·89	48·40	−0·49	66 5 21·4	23·4	+2·0	*g*
24 8 53 18	„	− 6 44·88	+12 54·0	1	4 54 49·80	49·38	−0·42	66 5 22·8	20·9	−1·9	*h*
25 9 5 50	B.	+ 0 22·54	− 1 2·7	4	4 56 32·66	32·27	−0·39	66 0 50·0	54·4	+4·4	*i*
25 9 5 50	„	+ 0 19·06	+10 43·2	4	4 56 32·46	32·27	−0·19	66 0 55·9	54·4	−1·5	*j*
25 9 5 50	„	− 5 1·97	+ 8 24·2	4	4 56 32·71	32·27	−0·44	66 0 53·0	54·4	+1·4	*h*
25 9 14 0	„	− 9 6·18	+ 9 52·3	3	4 56 33·28	32·85	−0·43	66 0 51·5	53·0	+1·5	*k*
25 9 14 0	„	− 9 57·61	+17 3·5	3	4 56 33·30	32·85	−0·45	66 0 50 7	53·0	+2·3	*l*
27 9 15 33	H.	− 1 36·09	− 0 15·3	7	4 59 58·57	58·18	−0·39	65 52 13·5	16·4	+2 9	*h*

The means of the apparent errors of tabular places, weighted proportionally to the number of comparisons with each star, give results as follows :—

	Day and hour d h	Error of Tab. R.A.	Error of Tab. N.P.D.	Error of Tab. Longitude.	Error of Tab. N.P.D.
Mars	Ap. 21 10	+0·20	−0·8	+2·8	−0·5
Ceres	Ap. 21 20	−0·34	+2·9	−4·9	+2·4

Comparison Stars.

Star's Name.	R.A. 1893·0. h m s	N.P.D. 1893·0. ° ′ ″	Authority.
a. W.B. (2) IV., 843	4 40 18·80	66 51 52·0	Berlin Zones, 17, 38, 41.
b. W.B. (2) IV., 918	4 43 20·32	66 47 25·2	„ „ 11, 17, 38, 41.
c. W.B. (2) IV., 975	4 45 54·04	66 25 45·9	„ „ 11, 17, 206, 212.
d. Lalande, 9145, –6, –7	4 47 15·57	66 37 25·0	„ „ 11, 17, 38, 41, and 2 Paris Observations.
e. B.D. + 23°, 766	4 48 50	66 30	Bonn Observations, vol. iv.
f. W.B. (2) IV., 1168	4 53 54·02	65 59 54·1	Berlin Zones, 38.
g. W.B. (2) IV., 1213	4 55 45·82	66 7 38·7	„ „ 215.
h. 103 Tauri	5 1 35·37	65 52 36·2	Greenwich 1880 Catalogue, and Greenwich Observations, 1891–92.
i. W.B. (2) IV., 1226	4 56 10·84	66 1 59·9	Berlin Zones, 215.
j. W.B. (2) IV., 1227	4 56 14·12	65 50 20·0	Weisse's Bessel.
k. W.B. (2) V., 53	5 5 40·13	65 51 6·7	Berlin Zones, 190, 208.
l. W.B. (2) V. 93, 94	5 6 31·58	65 43 54·8	„ „ 190, 208.

Notes.

The tabular places of *Mars* have been interpolated from the *Nautical Almanac*; those of *Ceres* have been supplied by the Superintendent of the *Nautical Almanac*.

The initials H., A.C., B., are those of Mr. Hollis, Mr. Crommelin, and Mr. Bryant respectively.

Royal Observatory, Greenwich:
1893 *May* 9.

Ephemeris for Physical Observations

Greenwich Noon.	P	L − O.	Diff.	B	A − L.	Apparent Diameter. Equat.	Phase.	Polar.
1893.	°	°		°	°	″	″	″
June 25	344·313	275·823	406	+3·031	− 7·993	34·30	0·17	32·10
27	344·455	276·229	401	·036	8·217	34·42	·18	32·22
29	344·597	276·630	395	·041	8·436	34·55	·19	32·34
July 1	344·738	277·025	390	·047	8·650	34·69	·20	32·46
3	344·878	277·415	384	·052	8·859	34·83	·21	32·59
5	345·017	277·799	379	+3·057	− 9·062	34·97	0·22	32·73
7	345·154	278·178	373	·062	9·259	35·12	·23	32·87
9	345·289	278·551	366	·068	9·451	35·27	·24	33·01
11	345·423	278·917	360	·073	9·636	35·43	·25	33·16
13	345·556	279·277	353	·078	9·815	35·59	·26	33·31
15	345·687	279·630	346	+3·083	− 9·987	35·76	0·27	33·46
17	345·816	279·976	340	·088	10·152	35·93	·28	33·62
19	345·942	280·316	332	·093	10·310	36·10	·29	33·79
21	346·067	280·648	324	·098	10·461	36·28	·30	33·96
23	346·189	280·972	316	·103	10·604	36·47	·31	34·13
25	346·308	281·288	309	+3·108	−10·740	36·66	0·32	34·31
27	346·426	281·597	300	·113	10·868	36·85	·33	34·49
29	346·541	282·897	292	·118	10·987	37·05	·34	34·67
31	346 653	282·189	284	·122	11·098	37·25	·35	34·86
Aug. 2	346·762	282·473	275	·127	11·201	37·46	·36	35·05
4	346·868	282·748	265	+3·132	−11·295	37·67	0·36	35·25
6	346·971	283·013	256	·137	11·380	37·88	·37	35·45
8	347 070	283·269	246	·142	11·455	38·10	·38	35·66
10	347·166	283·515	237	·146	11·521	38·32	·39	35·87
12	347·259	283·752	227	·151	11·577	38·55	·39	36·08
14	347·348	283·979	216	+3·155	−11·623	38·78	0·40	36·30
16	347·433	284·195	205	·160	11 658	39·02	·40	36·52
18	347·514	284·400	195	·165	11·683	39·26	·41	36·74
20	347·591	284·595	184	·169	11·697	39·50	·41	36·97
22	347 664	284·779	172	·174	11·700	39·74	·41	37·20
24	347·732	284·951	161	+3·179	−11·692	39·99	0·41	37·43
26	347·796	285 112	150	·183	11·673	40·24	·42	37·66
28	347·856	285·262	137	·188	11·642	40·50	·42	37·90

of Jupiter, 1893-94. By A. Marth.

Greenwich Noon.	Longitude of ☿'s Central Meridian. (877°·90) I.	(870°·27). II.	Corr. for Phase.	Light-time.	A − O.	B
1893.	°	°	°	m	°	°
Jun. 25	104·39	286·05	+0·28	47·210	267·8338	+3·0665
27	59·89	226·28	·29	47·038	268·0152	68
29	15·40	166·53	·31	46·861	268·1965	71
July 1	330·92	106·79	·33	46·679	268·3778	74
3	286·44	47·05	·34	46·493	268·5591	77
5	241·97	347·32	+0·36	46·302	268·7403	+3·0679
7	197·51	287·60	·37	46·107	268·9215	81
9	153·06	227·89	·39	45·907	269·1027	83
11	108·62	168·18	·40	45·703	269·2839	85
13	64·19	108·49	·42	45·495	269·4650	86
15	19·76	48·80	+0·43	45·283	269·6461	+3·0686
17	335·35	349·13	·45	45·068	269·8272	86
19	290·94	289·46	·46	44·849	270·0082	86
21	246·55	229·80	·48	44·626	270·1892	86
23	202·16	170·16	·49	44·400	270·3702	85
25	157·78	110·52	+0·50	44·171	270·5512	+3·0685
27	113·42	50·89	·51	43·939	270·7321	84
29	69·06	351·27	·52	43·705	270·9130	82
31	24·71	291·66	·53	43·468	271·0939	80
Aug. 2	340·37	232·06	·54	43·228	271·2747	78
4	296·05	172·47	+0·55	42·986	271·4555	+3·0675
6	251·73	112·90	·56	42·742	271·6363	72
8	207·42	53·33	·57	42·497	271·8170	69
10	163·13	353·77	·58	42·249	271·9977	66
12	118·84	294·22	·58	42·000	272·1784	62
14	74·57	234·69	+0·59	41·750	272·3591	+3·0658
16	30·31	175·17	·59	41·498	272·5397	54
18	346·05	115·65	·59	41·246	272·7203	49
20	301·81	56·15	·59	40·994	272·9009	44
22	257·58	356·66	·59	40·741	273·0814	39
24	213·36	297·18	+0·59	40·488	273·2619	+3·0634
26	169·16	237·71	·59	40·236	273·4424	28
28	124·96	178·25	·59	39·983	273·6228	22

Greenwich Noon.	P	L−O.	Diff.	B	A−L.	Apparent Diameter. Equat.	Phase.	Polar.
1893	°	°		°	°	″	″	″
Aug. 30	347·911	285·399	126	·192	11·599	40·75	·42	38·14
Sept. 1	347·961	285·525	114	·196	11·544	41·01	·41	38·38
3	348·006	285·639	101	+3·201	−11·477	41·27	0·41	38·63
5	·047	285·740	88	·205	11·398	41·54	·41	38·87
7	·083	285·828	75	·210	11·306	41·80	·41	39·12
9	·113	285·903	62	·214	11·201	42·07	·40	39·37
11	·138	285·965	49	·218	11·083	42·33	·39	39·62
13	348·158	286·014	36	+3·222	−10·952	42·60	0·39	39·87
15	·173	286·050	23	·226	10·808	42·87	·38	40·12
17	·183	286·073	9	·230	10·650	43·13	·37	40·37
19	·187	286·082	4	·234	10·479	43·40	·36	40·62
21	·185	286·078	18	·238	10·295	43 66	·35	40·86
23	348·178	286 060	31	+3·241	−10·097	43·93	0·34	41·11
25	·166	286·029	44	·245	9·886	44·19	·33	41·35
27	·149	285·985	58	·248	9·662	44·45	·32	41·60
29	·126	285·927	71	·251	9·424	44·70	·30	41·84
Oct. 1	·098	285·856	84	·254	9·173	44·95	·29	42·07
3	348·064	285·772	97	+3·256	− 8·909	45·20	0·27	42·30
5	348·026	285·675	111	·259	8·632	45·44	·26	42·53
7	347·982	285·564	123	·261	8·341	45·68	·24	42·75
9	347·933	285·441	136	·263	8·038	45·91	·23	42·97
11	347·879	285·305	148	·265	7·723	46·14	·21	43·18
13	347·820	285·157	160	+3·267	− 7·395	46·35	0·19	43·38
15	347·757	284 997	171	·268	7·056	46·56	·18	43·58
17	347·690	284·826	182	·268	6·705	46·76	·16	43·76
19	347·618	284·644	193	·269	6 343	46·95	·14	43·94
21	347·542	284·451	203	·269	5·971	47·14	·13	44·11
23	347·463	284·248	212	+3·269	− 5·589	47·31	0·11	44·27
25	347·380	284·036	221	·268	5·197	47·47	·10	44·42
27	347·293	283·815	230	·268	4·797	47·62	·08	44·56
29	347·203	283·585	237	·267	4·388	47·75	·07	44·69
31	347·111	283·348	244	·265	3·971	47·88	·06	44·81
Nov. 2	347·016	283·104	251	+3·263	− 3·547	47 99	0·05	44·91
4	346·919	282·853	257	·260	3·117	48·09	·04	45·00
6	346·820	282·596	261	·257	2·681	48·17	·03	45·08
8	346·720	282·335	266	·254	2·241	48·24	·02	45·15
10	346·618	282·069	269	·250	1·796	48·30	·01	45·20

Greenwich Noon.	Longitude of ♃'s Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Light-time.	Δ−0.	*B*
1893.	°	°	°	m	°	°
Aug. 30	80·78	118·81	·58	39·732	273·8032	·0616
Sept. 1	36·61	59·37	·58	39·481	273·9836	·0610
3	352·44	359·95	+0·57	39·231	274·1639	+3·0603
5	308·29	300·54	·56	38·983	274·3442	·0596
7	264·16	241·14	·56	38·736	274·5245	·0589
9	220·03	181·75	·55	38·492	274·7047	·0581
11	175·91	122·38	·53	38·250	274·8849	·0573
13	131·81	63·01	+0·52	38·010	275·0651	+3·0564
15	87·72	3·66	·51	37·773	275·2452	·0555
17	43·64	304·32	·49	37·540	275·4253	·0546
19	359·57	244·99	·48	37·310	275·6054	·0537
21	315·51	185·67	·46	37·084	275 7855	·0527
23	271·47	126·36	+0·44	36·862	275·9655	+3·0517
25	227·43	67 06	·43	36·644	276·1455	·0507
27	183·40	7·78	·41	36·431	276·3254	·0496
29	139·39	308·50	·39	36·223	276·5053	·0485
Oct. 1	95·39	249·23	·37	36·021	276·6852	·0474
3	51·39	189·98	+0·35	35·824	276·8650	+3·0463
5	7·40	130·73	·32	35·632	277·0448	·0451
7	323·43	71·49	·30	35·447	277·2246	·0439
9	279·46	12·26	·28	35·269	277·4043	·0427
11	235·50	313·04	·26	35·098	277·5840	·0414
13	191·55	253·83	+0 24	34·933	277·7637	+3·0401
15	147·60	194·63	·22	34·776	277·9433	·0388
17	103·66	135·43	·20	34·627	278·1229	·0374
19	59·73	76·24	·18	34·486	278·3025	·0360
21	15·80	17·05	·16	34·353	278·4820	·0346
23	331·88	317·87	+0·14	34·229	278·6615	+3·0332
25	287·96	258·69	·12	34·113	278·8410	·0317
27	244·05	199·51	·10	34·006	279·0204	·0302
29	200·14	140·34	·08	33·909	279·1998	·0287
31	156·23	81·17	·07	33·821	279·3791	·0272
Nov. 2	112·33	22·00	+0·06	33·742	279·5584	+3·0256
4	68·42	322·84	·04	33·673	279·7377	·0240
6	24·51	263·67	·03	33·614	279·9169	·0224
8	340·60	204·50	·02	33·565	280·0961	·0207
10	296·69	145·33	·01	33·526	280·2753	·0190

Greenwich Noon.	P	L−O.	Diff.	B	A−L.	Apparent Diameter. Equat.	Phase.	Polar.
1893.	°	°		°	°	″	″	″
Nov. 12	346·515	281·800	271	+3·246	− 1·348	48·34	0·01	45·24
14	346·412	281·529	273	·241	0·898	48·37	·00	45·26
16	346·308	281·256	273	·236	− 0·446	48·38	·00	45·27
18	346·205	280·983	273	·231	+ 0·006	48·37	·00	45·27
20	346·102	280·710	272	·225	0·458	48·35	·00	45·25
22	346·000	280·438	270	+3·219	+ 0·909	48·32	·00	45·22
24	345·898	280·168	267	·212	1·358	48·27	·01	45·17
26	345·798	279·901	264	·205	1·804	48·21	·01	45·11
28	345·700	279·637	260	·198	2·247	48·13	·02	45·04
30	345 604	279·377	255	·190	2·686	48·04	·03	44·96
Dec. 2	345·510	279·122	248	+3·182	+ 3·119	47·93	0·04	44·86
4	345·418	278·874	242	·174	3·546	47·81	·05	44·75
6	345·328	278·632	235	·166	3·967	47·68	·06	44·62
8	345·242	278·397	227	·157	4·381	47·53	·07	44·48
10	345·159	278·170	218	·148	4·786	47·37	·08	44·33
12	345·080	277·952	208	+3·138	+ 5·182	47·20	0·10	44·17
14	345·004	277·744	198	·129	5·569	47·02	·11	44·00
16	344·932	277·546	188	·120	5·946	46·83	·13	43·82
18	·864	277·358	177	·110	6·313	46·62	·14	43·63
20	·800	277·181	166	·100	6·668	46·41	·16	43·43
22	344·740	277·015	154	+3·090	+ 7·012	46·19	0·17	43·23
24	·685	276·861	141	·080	7·344	45·96	·19	43·02
26	·634	276·720	129	·070	7·664	45·73	·20	42·80
28	·597	276·591	116	·060	7·971	45·49	·22	42·57
30	·545	276·475	103	·050	8·265	45·24	·23	42·34
1894.								
Jan. 1	344·508	276·372	90	+3·040	+ 8·547	44·98	0·25	42·10
3	·476	·282	76	3·030	8·815	44·72	·26	41·85
5	·448	·206	63	3·021	9·069	44·46	·28	41·60
7	·425	·143	49	3 011	9·310	44·19	·29	41·35
9	·407	·094	35	3·001	9·537	43·92	·30	41·10
11	344·394	276·059	21	+2 991	+ 9·750	43·64	0·32	40·85
13	·386	·038	8	2·982	9·949	43·37	·33	40·59
15	·383	·030	7	2·973	10·134	43·09	·34	40·33
17	·384	·037	21	2·964	10·305	42·81	·35	40·07
19	·391	·058	34	2·955	10·462	42·53	·35	39·81
21	344·402	276·092	47	+2·946	+10·606	42·25	0·36	39·55

Greenwich Noon.	Longitude of ☿'s Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Light-time.	A − 0.	B
1893.	°	°	°	m	°	°
Nov. 12	252·78	86·16	+0·01	33·498	280·4544	+3·0172
14	208·86	26·98	·00	33·480	280·6335	·0154
16	164·94	327·80	...	33·472	280·8126	·0136
18	121·01	268·61	...	33·475	280·9916	·0118
20	77·07	209·41	...	33·488	281·1706	·0100
22	33·13	150·21	−0·00	33·511	281·3495	+3·0081
24	349·18	91·00	·01	33·545	281·5284	·0062
26	305·22	31·78	·01	33·590	281·7072	·0043
28	261·25	332·55	·02	33·644	281·8860	·0023
30	217·27	273·31	·03	33·709	282·0648	3·0003
Dec. 2	173·28	214·06	−0·04	33·784	282·2436	+2·9983
4	129·28	154·80	·05	33·869	282·4223	·9962
6	85·26	95·52	·07	33·963	282·6010	·9941
8	41·23	36·23	·08	34·068	282·7796	·9920
10	357·19	336·93	·10	34·182	282·9582	·9898
12	313·13	277·61	−0·12	34·305	283·1368	+2·9877
14	269·06	218·28	·14	34·438	283·3153	·9855
16	224·97	158·93	·15	34·579	283·4938	·9833
18	180·87	99·57	·17	34·729	283·6722	·9811
20	136·75	40·19	·19	34·888	283·8506	·9788
22	92·61	340·80	−0·21	35·054	284·0290	+2·9765
24	48·46	281·39	·24	35·228	284·2073	·9742
26	4·29	221·96	·26	35·410	284·3856	·9718
28	320·10	162·51	·28	35·599	284·5639	·9694
30	275·90	103·05	·30	35·795	284·7421	·9670
1894.						
Jan. 1	231·68	43·57	−0·32	35·998	284·9203	+2·9646
3	187·44	344·08	·34	36·207	285·0984	·9621
5	143·19	284·56	·36	36·422	285·2765	·9596
7	98·92	225·03	·38	36·643	285·4546	·9571
9	54·63	165·48	·40	36·869	285·6326	·9546
11	10·32	105·92	−0·41	37·101	285·8106	+2·9520
13	326·00	46·34	·43	37·337	285·9885	·9494
15	281·66	346·74	·45	37·577	286·1664	·9468
17	237·30	287·13	·46	37·822	286·3443	·9441
19	192·93	227·50	·48	38·070	286·5221	·9414
21	148·54	167·85	−0·49	38·321	286·6999	+2·9387

Greenwich Noon.		P	L−O.	Diff.	B	A−L.	Apparent Diameter. Equat.	Phase.	Polar.
1894.		°	°		°	°	″	″	″
Jan.	23	344·418	·139	61	2·937	10·736	41·98	·37	39·28
	25	·438	·200	75	2·929	10·852	41·70	·37	39·02
	27	·464	·275	88	2·920	10·955	41·42	·38	38·76
	29	·494	·363	101	2·912	11·045	41·14	·38	38·50
	31	344·529	276·464	113	+2·904	+11·122	40 87	0·38	38·25
Feb.	2	·569	·577	127	2·897	11·186	40·60	·39	37·99
	4	·613	·704	139	2·889	11·237	40·33	·39	37·74
	6	·662	·843	151	2·882	11·276	40·06	·39	37·49
	8	·715	276·994	163	2·874	11·302	39·80	·39	37·24
	10	344·773	277·157	176	+2·867	+11·316	39·54	0·38	37·00
	12	·835	277·333	187	2·861	11·318	39·28	·38	36·76
	14	·901	277·520	198	2·854	11·308	39·02	·38	36·52
	16	344·972	277·718	209	2·848	11·287	38·77	·37	36·28
	18	345·047	277·927	220	2·841	11·255	38·52	·37	36·04
	20	345·126	278 147	231	+2·835	+11·212	38·28	0·37	35·83
	22	345·209	278·378	240	2·829	11·159	38·04	·36	35·60
	24	345·296	278·618	250	2·823	11·095	37·81	·35	35·38
	26	345·387	278·868	261	2·818	11·021	37·58	·35	35·17
	28	345·482	279·129	270	2·813	10·938	37·35	·34	34·96
Mar.	2	345·581	279·399	279	+2·807	+10·845	37·13	0·33	34·75
	4	345·684	279·678	288	2·802	10·743	36·91	·32	34·55
	6	345·791	279·966	297	2·797	10·632	36·70	·32	34·35
	8	345·901	280·263	306	2·792	10·512	36·49	·31	34·15
	10	346·015	280·569	314	2·787	10·383	36·29	·30	33·96
	12	346·132	280·883	322	+2·783	+10·246	36·09	0·29	33·78
	14	346·253	281·205	329	2·778	10·101	35·90	·28	33·60
	16	346·378	281·534	336	2·774	9·948	35·71	·27	33·42
	18	346·506	281·870	344	2·770	9·787	35·53	·26	33·25
	20	346·637	282·214	351	2·765	9·620	35·35	·25	33·08
	22	346·771	282·565	358	+2·761	+ 9·446	35·18	0·24	32·92
	24	346·909	282·923	364	2·756	9·265	35·01	·23	32·76
	26	347·050	283·287	370	2·752	9·078	34·84	·22	32·61
	28	347·193	283·657	376	2·748	8·884	34·68	·21	32·46
	30	347·340	284·033	382	2·744	8·684	34·53	·20	32·31
Apr.	1	347·489	284·415		+2·740	+ 8·478	34·38	0·19	32·17

Greenwich Noon.	Longitude of ♃'s Central Meridian. (877°·90) I.	(870°·27). II.	Corr. for Phase.	Light-time.	Δ−0.	*B*
1894.	°	°	°	m	°	°
Jan. 23	104·14	108·19	·50	38·576	286·8776	·9359
25	59·72	48·51	·51	38·833	287·0553	·9331
27	15·29	348·82	·52	39·093	287·2330	·9303
29	330·84	289·11	·53	39·356	287·4106	·9275
31	286·38	229·39	−0·54	39·620	287·5882	+2·9246
Feb. 2	241·91	169·66	·54	39·885	287·7657	·9217
4	197·42	109·91	·55	40·152	287·9432	·9188
6	152·92	50·15	·55	40·420	288·1207	·9159
8	108·40	350·38	·55	40·689	288·2981	·9129
10	63·87	290·59	−0·56	40·958	288·4755	+2 9099
12	19·33	230·79	·56	41·227	288·6528	·9069
14	334·78	170·98	·56	41·496	288·8301	·9038
16	290·22	111·16	·55	41·764	289·0073	·9007
18	245·65	51·33	·55	42 032	289·1845	·8976
20	201·07	351·49	−0·55	42·298	289·3617	+2·8945
22	156·47	291·64	·54	42·564	289·5388	·8913
24	111·87	231·78	·54	42·828	289·7159	·8881
26	67·26	171·91	·53	43·090	289·8929	·8849
28	22·64	112·03	·52	43·350	290·0699	·8816
Mar. 2	338·01	52·14	−0·51	43·609	290·2468	+2·8783
4	293·38	352·25	·50	43·866	290·4237	·8750
6	248·74	292·35	·49	44·120	290·6006	·8717
8	204·09	232·44	·48	44·371	290·7774	·8683
10	159·43	172·52	·47	44·619	290·9542	·8649
12	114·77	112·60	−0·46	44·863	291·1309	+2·8615
14	70·10	52·67	·44	45·105	291·3076	·8581
16	25·42	352·74	·43	45·343	291·4842	·8546
18	340·74	292·80	·42	45·577	291·6608	·8511
20	296·06	232·86	·40	45·808	291·8374	·8476
22	251·37	172·91	−0·39	46·034	292·0139	+2·8441
24	206·68	112·96	·37	46·256	292·1904	·8405
26	161·98	53·01	·36	46·474	292·3668	·8369
28	117·28	353·05	·34	46·688	292·5432	·8333
30	72·58	293·09	·33	46·897	292·7195	·8297
Apr. 1	27·87	233·12	−0·31	47·102	292·8958	+2·8261

P is the position-angle of the polar axis of *Jupiter*; L − O + 180° the jovicentric longitude of the Earth, reckoned in the assumed plane of the planet's equator from O, the point of the vernal equinox of *Jupiter's* northern hemisphere, or the point of the descending node of the planet's equator on its orbit. B denotes the jovicentric latitude of the Earth above *Jupiter's* equator; A − L the annual parallax or the difference between the jovicentric longitudes of the Sun and the Earth. For the computation of the apparent diameters of the disc, the values deduced by Schur (*Astron. Naehr.*, vol. 129, p. 14), which were adopted in the ephemeris for the preceding apparition, have been retained.

The two values of the "Longitude of ♃'s Central Meridian" have been computed with the same rates of rotation as in the ephemerides for some preceding years, and without any shifting of the zero-meridians from the positions adopted in the last ephemeris. The differences of successive values of the longitudes for the intervals of two days vary for System I. between 1755°·29 and 1756°·10; and for System II. between 1740°·03 and 1740°·84. The addition of the "correction for phase" to the longitude of the central meridian gives the longitude of the meridian which bisects the illuminated disc. The following is a list of Greenwich mean times, when the zero-meridian in the assumed two systems of longitudes will pass the middle of the illuminated disc:—

		I. (877°·90)	II. (870°·27)		I. (877°·90)	II. (870°·27)
1893		h m	h m	1893	h m	h m
June	25	16 49·5	21 53·5	July 7	24 7·1	21 50·7
	26	22 21·3	17 45·0	8	9 57·7	7 46·5
	27	8 11·9	13 36·6		19 48·3	17 42·2
		18 2·4	23 32·3	9	15 29·4	13 33·7
	28	13 43 6	9 28·1		25 20·0	23 29·5
		23 34·2	19 23·9	10	11 10·6	9 25·3
	29	19 15·4	15 15·4		21 1·2	19 21·0
	30	14 56·6	11 7·0	11	16 42·3	15 12·5
		24 47·2	21 2·7	12	12 23·4	11 4·0
July	1	20 28·3	16 54·3		22 14·0	20 59·8
	2	16 9·5	22 41·6	13	17 55·2	16 51·3
	3	11 50·7	8 37·3	14	13 36·3	12 42·8
		21 41·3	18 33·1		23 26·9	22 38·5
	4	17 22·4	14 24·6	15	9 17·4	8 34·3
	5	22 54·2	20 11·9		19 8·0	18 30·0
	6	18 35·4	16 3·4	16	14 49·1	14 21·5
	7	14 16·5	11 54·9	17	0 39·7	0 17·3

1893		I. (877°·90) h m	II. (870°·27) h m
July	17	10 30·3	10 13·0
		20 20·8	20 8·7
	18	16 2·0	16 0·2
	19	11 43·1	11 51·7
		21 33·6	21 47·5
	20	17 14·8	17 38·9
	21	12 55·9	13 30·4
		22 46·4	23 26·1
	22	8 36·0	9 21·9
		18 27·6	19 17·6
	23	14 8·7	15 9·1
		23 59·2	25 4·8
	24	9 49·8	11 0·5
		19 40·3	20 56·3
	25	15 21·4	16 47·7
	26	11 2·6	12 39·2
		20 53·1	22 34·9
	27	16 34·2	18 26·4
	28	12 15·3	14 17·9
		22 5·9	24 13·6
	29	7 56·4	10 9·3
		17 47·0	20 5·0
	30	13 28·0	6 0·8
		23 18·6	15 56·5
	31	9 9·1	11 47·9
		18 59·7	21 43·6
Aug.	1	14 40·8	7 39·4
		24 31·3	17 35·1
	2	10 21·8	13 26·5
		20 12·4	23 22·2
	3	6 2·9	9 18·0
		15 53·5	19 13·7
	4	11 34·5	15 5·1
		21 25·1	25 0·8
	5	7 15·6	10 56·5
		17 6·1	20 52·3
	6	12 47·2	6 48·0
		22 37·8	16 43·7

1893		I. (877°·90) h m	II. (870°·27) h m
Aug.	7	8 28·3	12 35·1
		18 18·8	22 30·8
	8	13 59·9	8 26·5
		23 50·4	18 22·2
	9	9 40·9	14 13·6
		19 31·5	24 9·3
	10	15 12·5	10 5·1
		25 3·0	20 0·8
	11	10 53·6	15 52·2
		20 44·1	25 47·9
	12	6 34·6	11 43·6
		16 25·1	21 39·3
	13	12 6·2	7 35·0
		21 56·7	17 30·7
	14	7 47·2	13 22·1
		17 37·7	23 17·8
	15	13 18·8	9 13·5
		23 9·3	19 9·2
	16	8 59·8	15 0·6
		18 50·3	24 56·3
	17	14 31·4	10 51·9
		24 21·9	20 47·6
	18	10 12·4	6 43·3
		20 2·9	16 39·0
	19	5 53·4	12 30·4
		15 44·0	22 26·1
	20	11 25·0	8 21·8
		21 15·5	18 17·5
	21	7 6·0	24 8·9
		16 56·5	14 4·5
	22	12 37·5	10 0·2
		22 28·0	19 55·9
	23	8 18·6	5 51·6
		18 9·1	15 47·3
	24	13 50·1	11 38·6
		23 40·6	21 34·3
	25	9 31·1	7 30·0
		19 21·6	17 25·7

1893	I. (877°·90) h m	II. (870°·27) h m	1893	I. (877°·90) h m	II. (870°·27) h m
Aug. 26	15 2·6	13 17·0	Sept. 14	11 44·8	13 57·5
	24 53·1	23 12·7		21 35·3	23 53·1
27	10 43·6	9 8·4	15	7 25·7	9 48·7
	20 34·1	19 4·1		17 16·2	19 44·4
28	6 24·6	14 55·4	16	12 57·1	5 40·0
	16 15·1	24 51·1		22 47·6	15 35·7
29	11 56·1	10 46·8	17	8 38·1	11 26·9
	21 46·5	20 42·4		18 28·5	21 22·6
30	7 37·0	6 38·1	18	14 9·5	7 18·2
	17 27·5	16 33·8		23 59·9	17 13·9
31	13 8·5	12 25·1	19	9 50·4	13 5·1
	22 59·0	22 20·8		19 40·8	23 0·8
Sept. 1	8 49·5	8 16·5	20	5 31·3	8 56·4
	18 40·0	18 12·1		15 21·8	18 52·0
2	14 21·0	14 3·5	21	11 2·7	14 43·3
	24 11·5	23 59·1		20 53·1	24 38·9
3	10 2·0	9 54·8	22	6 43·6	10 34·6
	19 52·4	19 50·5		16 34·0	20 30·2
4	5 42·9	5 46·1	23	12 14·9	6 25·8
	15 33·4	15 41·8		22 5·4	16 21·4
5	11 14·4	11 33·1	24	7 55·8	12 12·7
	21 4·9	21 28·7		17 46·3	22 8·3
6	6 55·3	7 24·3	25	13 27·2	8 4·0
	16 45·8	17 20·0		23 17 6	17 59·6
7	12 26·8	13 11·4	26	9 8·1	13 50·8
	22 17·3	23 7·1		18 58·5	23 46·5
8	8 7·7	9 2·7	27	14 39·4	9 42·1
	17 58·2	18 58·4		24 29·9	19 37·7
9	13 39·2	14 49·7	28	10 20·3	5 33·3
	23 29·6	24 45·3		20 10·7	15 28·9
10	9 20·1	10 41·0	29	6 1·2	11 20·2
	19 10·6	20 36·6		15 51·6	21 15·8
11	14 51·5	6 32·3	30	11 32·5	7 11·4
	24 42·0	16 27·9		21 22·9	17 7·0
12	10 32·5	12 19·2	Oct. 1	7 13·4	12 58·3
	20 22·9	22 14·9		17 3·8	22 53·9
13	6 13·4	8 10·5	2	12 44·7	8 49·5
	16 3·9	18 6·2		22 35·1	18 45·1

1893	I. (877°·90) h m	II. (870°·27) h m	1893	I. (877°·90) h m	II. (870°·27) h m
Oct. 3	8 25·6	14 36·3	Oct. 22	5 5·1	5 18·3
	18 16·0	24 32·0		14 55·5	15 13·9
4	13 56·9	10 27·6	23	10 36·3	11 5·1
	23 47·3	20 23·2		20 26·7	21 0·6
5	9 37·8	6 18·8	24	6 17·1	6 56·2
	19 28·2	16 14·4		16 7·5	16 51·8
6	5 18·6	12 5·6	25	11 48·4	12 43·0
	15 9·0	22 1·2		21 38·8	22 38·6
7	10 49·9	7 56·8	26	7 29·2	8 34·2
	20 40·3	17 52·4		17 19·6	18 29·8
8	6 30·8	13 43·6	27	13 0·4	4 25·3
	16 21·2	23 39·2		22 50·8	14 20·9
9	12 2·1	9 34·8	28	8 41·2	10 12·0
	21 52·5	19 30·5		18 31·6	20 7·7
10	7 42·9	5 26·1	29	4 22·0	6 3·3
	17 33·3	15 21·7		14 12·4	15 58·9
11	13 14·2	11 12·9	30	9 53·3	11 50·0
	23 4·6	21 8·5		19 43·7	21 45·6
12	8 55·0	7 4·0	31	5 34·1	7 41·2
	18 45·5	16 59·6		15 24·5	17 36·8
13	14 26·3	12 50·8	Nov. 1	11 5·3	13 27·9
	24 16·7	22 46·4		20 55·7	23 23·5
14	10 7·1	8 42·0	2	6 46·1	9 19·1
	19 57·6	18 37·6		16 36·5	19 14·7
15	5 48·0	14 28·8	3	12 17·3	5 10·2
	15 38·4	24 24·4		22 7·7	15 5·8
16	11 19·2	10 20·0	4	7 58·1	10 57·0
	21 9·7	20 15·6		17 48·5	20 52·6
17	6 59·1	6 11·2	5	13 29·3	6 48·2
	16 50·5	16 6·8		23 19·7	16 43·7
18	12 31·3	11 58·0	6	9 10·2	12 34·9
	22 21·7	21 53·6		19 0·6	22 30·5
19	8 12·2	7 49·2	7	4 51·0	8 26·1
	18 2·6	17 44·7		14 41·4	18 21·6
20	13 43·4	13 35·9	8	10 22·2	4 17·2
	23 33·8	23 31·5		20 12·6	14 12·8
21	9 24·2	9 27·1	9	6 3·0	10 4·0
	19 14·7	19 22·7		15 53·4	19 59·5

1893	I. (877°·90) h m	II. (870°·27) h m	1893	I. (877°·90) h m	II. (870°·27) h m
Nov. 10	11 34·2	5 55·1	Nov. 29	8 13·3	6 32·3
	21 24·6	15 50·7		18 3·7	16 27·9
11	7 15·0	11 41·9	30	3 54·1	2 23·5
	17 5·4	21 37·5		13 44·6	12 19·1
12	2 55·8	7 33·0	Dec. 1	9 25·4	8 10·3
	12 46·2	17 28·6		19 15·9	18 5·9
13	8 27·1	3 24·2	2	5 6·3	4 1·5
	18 17·5	13 19·8		14 56·7	13 57·1
14	4 7·9	9 10·9	3	10 37·6	9 48·3
	13 58·3	19 6·5		20 28·0	19 44·0
15	9 39·1	5 2·1	4	6 18·5	5 39·6
	19 29·5	14 57·7		16 8·9	15 35·2
16	5 19·9	10 48·9	5	1 59·4	1 30·8
	15 10·3	20 44·4		11 49·8	11 26·4
17	10 51·1	6 40·0	6	7 30·7	7 17·7
	20 41·5	16 35·6		17 21·1	17 13·3
18	6 31·9	12 26·8	7	3 11·6	3 8·9
	16 22·4	22 22·4		13 2·0	13 4·6
19	2 12·8	8 18·0	8	8 42·9	8 55·8
	12 3·2	18 13·5		18 33·4	18 51·4
20	7 44·0	4 9·1	9	4 23·9	4 47·1
	17 34·4	14 4·7		14 14·3	14 42·7
21	3 24·8	9 55·9	10	9 55·2	10 34·0
	13 15·3	19 51·5		19 45·7	20 29·6
22	8 56·1	5 47·1	11	5 36·1	6 25·2
	18 46·5	15 42·7		15 26·6	16 20·9
23	4 36·9	1 38·3	12	1 17·1	2 16·5
	14 27·3	11 33·9		11 7·5	12 2·2
24	10 8·2	7 25·1	13	6 48·5	8 3·4
	19 58·6	17 20·7		16 38·9	17 59·1
25	5 49·0	3 16·3	14	2 29·4	3 54·7
	15 39·4	13 11·8		12 19·9	13 50·4
26	1 29·9	9 3·0	15	8 0·8	9 41·6
	11 20·3	18 58·6		17 51·3	19 37·3
27	7 1·1	4 54·2	16	3 41·7	5 32·9
	16 51·6	14 49·8		13 31·2	15 28·6
28	2 42·0	0 45·4	17	9 13·1	1 24·2
	12 32·4	10 41·1		19 3·6	11 19·9

	I. (877°·90)	II. (870°·27)
1893	h m	h m
Dec. 18	4 54·1	7 11·2
	14 44·6	17 6·8
19	10 25·5	3 2·5
	20 16·0	12 58·2
20	6 6·5	8 49·5
	15 57 0	18 45·1
21	1 47·5	4 40·8
	11 37·9	14 36·5
22	7 18·9	10 27·8
	17 9·4	20 23·5
23*	2 59·9	6 19·1
	12 50·4	16 14·8
24	8 31·1	2 10·5
	18 21·9	12 6·1
25	4 12·4	7 57·5
	14 2·9	17 53·2
26	9 43·9	3 48·8
	19 34·4	13 44·5
27	5 24·9	9 35·9
	15 15·4	19 31·6
28	1 5·9	5 27·2
	10 56·4	15 22·9
29	6 37·4	1 18·6
	16 27·9	11 14·3
30	2 18·4	7 5·7
	12 8·9	17 1·4
31	7 50·0	2 57·0
	17 40·5	12 52·7
1894.		
Jan. 1	3 31·0	8 44·1
	13 21·5	18 39·8
2	9 2·6	4 35·5
	18 53·1	14 31 2

	I. (877° 90)	II. (870°·27)
1894	h m	h m
Jan. 3	4 43·6	0 26·9
	14 34·1	10 22·6
4	0 24·7	6 14·0
	10 15·2	16 9·7
5	5 56·2	2 5·4
	15 46·8	12 1·1
6	1 37·3	7 52·5
	11 27·8	17 48·3
7	7 8·9	3 44·0
	16 59·4	13 39·7
8	2 50·0	9 31·1
	12 40·5	19 26·8
9	8 21·6	5 22·5
	18 12·1	15 18·3
10	4 2·7	1 14·0
	13 53·2	11 9·7
11	9 34·3	7 1·1
	19 24·8	16 56·9
12	5 15·4	2 52·6
	15 5·9	12 48·3
13	0 56·5	8 39·8
	10 47·0	18 35·5
14	6 28·1	4 31·2
	16 18·7	14 26·9
15	2 9·2	0 22·7
	11 59·8	10 18·4
16	7 40·9	6 9·9
	17 31·5	16 5·6
17	3 22·0	2 1·3
	13 12·6	11 57·1
18	8 53·7	7 48·6
	18 44·3	17 44·3
19	4 34·9	3 40·1

* On Dec. 23 a Transit of *Venus* across the Sun's disc will take place for *Jupiter's* system. On page 162 of vol. xlvi. of the *Monthly Notices* a list is given of the transits which have occurred since 1830, to which may now be added

1893 Dec. 23·4 hel. long. 59°·5.

	I. (877°·90)	II. (870°·27)
1894	h m	h m
Jan. 19	14 25·4	13 35·8
20	10 6·5	9 27·3
21	5 47·7	5 18·8
	15 38·3	15 14·5
22	1 28·8	1 10·3
	11 19·4	11 6·0
23	7 0·5	6 57·5
	16 51·1	16 53·3
24	2 41·7	2 49·0
	12 32·3	12 44·8
25	8 13·4	8 36·3
26	3 54·6	4 27·8
	13 45·2	14 23·6
27	9 26·3	10 15·1
28	5 7·5	6 6·6
	14 58·1	16 2·4
29	0 48·7	1 58·2
	10 38·3	11 54·0
30	6 20·5	7 45·5
31	2 1·7	3 37·0
	11 52·2	13 32·8
Feb. 1	7 33·4	9 24·3
2	3 14·6	5 15·9
	13 5·2	15 11·7
3	8 46·4	11 3·2
4	4 27·6	6 54·8
5	0 8·8	2 46·3
	9 59·4	12 42·1
6	5 40·6	8 33·7
7	1 21·8	4 25·3
	11 12·4	14 21·1
8	6 53·7	10 12·6
9	2 34·9	6 4·2
10	8 6·7	11 51·6
11	3 48·0	7 43·2
12	9 19·8	3 34·8
13	5 1·0	9 22·1
14	10 32·9	5 13·7

	I. (877°·90)	II. (870°·27)
1894	h m	h m
Feb. 15	6 14·1	11 1·1
16	1 55·4	6 52·7
17	7 27·2	12 40·1
18	3 8·5	8 31·8
19	8 40·4	4 23·4
20	4 21·6	10 10·8
21	9 53·5	6 2·4
22	5 34·8	11 49·8
23	1 16·1	7 41·5
24	6 48·0	13 28·9
25	2 29·2	9 20·5
26	8 1·1	5 12·2
27	3 42·4	1 3·8
	13 33·1	10 59·6
28	9 14·3	6 51·3
Mar. 1	4 55·6	2 42·9
	14 46·3	12 38·7
2	10 27·5	8 30·4
3	6 8·8	4 22·0
4	1 50·1	0 13·7
	11 40·8	10 9·5
5	7 22·0	6 1·1
6	3 3·3	1 52·8
	12 54·0	11 48·6
7	8 35·3	7 40·3
8	4 16·6	3 31·9
	14 7·2	13 27·7
9	9 48·5	9 19·4
10	5 29·8	5 11·1
	15 20·5	15 6·9
11	11 1·8	10 58·6
12	6 43·1	6 50·2
13	2 24·4	2 41·9
	12 15·1	12 37·7
14	7 56·4	8 29·4
15	3 37·7	4 21·1
	13 28·3	14 16·9
16	9 9·6	10 8·6

	I. (877°·90)	II. (870°·27)		I. (877°·90)	II. (870°·27)
1894	h m	h m	1894	h m	h m
March 17	4 51·0	6 0·2	March 24	4 12·2	6 49·5
18	10 22·9	11 47·7	25	9 44·2	12 37·0
19	6 4·3	7 39·4	26	5 25·5	8 28·7
20	11 36·2	13 26·9	28	6 38·8	10 7·9
21	7 17·6	9 18·6	29	2 20·1	5 59·6
22	2 58·9	5 10·3	30	7 52·1	11 47·1
23	8 30·9	10 57·8	31	3 33·4	7 38·8

The intervals between successive passages or crossings vary in System I. between $9^h\ 50^m{\cdot}40$ and $50^m{\cdot}67$ and in II. between $9^h\ 55^m{\cdot}58$ and $55^m{\cdot}85$.

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Errata in Monthly Notices, liii., 1 (1891 *November*), *p.* 27, *Wolf's Comet* (*b* 1891).

$\mathscr{E} - *d$ N.P.D., for $+\ 2'\ 25''{\cdot}7$ read $+\ 2'\ 28''{\cdot}2$.

$\mathscr{E} - *e$ N.P.D., for $+13\ 31{\cdot}0$ read $+14\ 5{\cdot}6$.

$\mathscr{E} - *f$ N.P.D., for $-\ 1\ 20{\cdot}5$ read $-\ 1\ 18{\cdot}8$.

Appt. N.P.D. of $\mathscr{E}$ from $*e$ for $77^\circ\ 11'\ 44''{\cdot}2$ read $77^\circ\ 12'\ 26''{\cdot}7$.

Appt. N.P.D. of $\mathscr{E}$ from $*f$ for $77\ 40\ 50{\cdot}1$ read $77\ 40\ 48{\cdot}4$.

In the N.P.D. of $\mathscr{E}$ deduced from $*e$ the N.P.D. of the latter given in the footnote, viz., $76^\circ\ 58'\ 41''{\cdot}5$, has been adopted, as it was confirmed by subsequent observations.

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